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SUMMARY OF EFFORTS EXPENDED ON THE CONCEPT OF "DYNAMIC UPDATE OF A MICROFILM FILE"

TECHNICAL REPORT NO. ESD-TR-65-90

AUGUST 1965

G. Barboza

ESLT

Prepared for

SUPPORT SYSTEMS DIVISION
DEPUTY FOR ADVANCED PLANNING
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 614.1

Prepared by

THE MITRE CORPORATION
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FOREWORD

The concept of Dynamic Update of a Microfilm File and the subsequent design, development and fabrication of the feasibility prototype could not have been possible without the contributions of the following individuals. The author gratefully acknowledges the efforts of these people: Theodore E. Allen, Victor A. DeMarines, Robert J. Johnson, Roger M. Robillard, Robert D. Thompson, and Walter J. Cook.

Many other people, too numerous to mention, provided valuable assistance in the fabrication and assembly of the prototype hardware in addition to sample data base preparation. To these individuals I say -- a job well done.

ABSTRACT

This document describes the development of the concept of "Dynamic Update of a Microfilm File." Included is a complete description of the prototype hardware that was designed and fabricated to prove the feasibility of combining magnetic and photographic techniques of information storage. The prototype hardware possesses the capability of information storage, rapid update, retrieval and display.

REVIEW AND APPROVAL

This technical documentary report has been reviewed and is approved.

Dale D. Ryder

DALE D. RYDER
Lt Colonel, USAF
Project Officer

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SECTION I

INTRODUCTION

This document is a detailed summary of the efforts expended on the development of the concept of a dynamically updatable microfilm information storage, retrieval and display system. Included in this report is a description of the hardware that was designed, developed and fabricated as a feasibility prototype.

A complete set of logic drawings is included in Appendix I. A description of the commercial microfilm equipment obtained for the program is contained in Appendix II. Appendix III contains a description of the data base prepared to illustrate the functional capability of dynamic updating.

SECTION II

DEVELOPMENT OF THE CONCEPT

All command and control systems, planned or operational, have a standing requirement for the compact storage and rapid retrieval of information. Microfilm and other photographic media were studied to determine their suitability for application in command and control. Some of the characteristics of microfilm which are desirable in command and control are:

(1) High information packing density;

(2) Easy storage of documents, graphs, photographs, maps and weather charts;

(3) Rapid retrieval;

(4) Information readily displayed by projection;

(5) High resolution and good definition;

(6) Information easily reproduced.

Physically, microfilm in reel form appears to lend itself more readily to handling and transporting than do other microfilm forms (i.e., chips, strips, scroll, etc.). A particularly convenient form of storage is provided by the somewhat classic magazine. Magazines are available which allow rapid loading and automatic threading of up to 100 feet of film.

A serious disadvantage of present microfilm systems is the nonexistance of methods and equipment for rapid updating. The concept described here utilizes a technique which makes use of the advantages of a reel microfilm system supplemented with dynamic update and consecutive search capabilities.

Dynamic updating is accomplished by the use of a magnetic strip on the microfilm in conjunction with read/write circuits. Consecutive search capability (i. e., store present position and search forward or reverse from it) provides a significant decrease in the retrieval response time[1] relative to commercial hardware (see Figure 1).

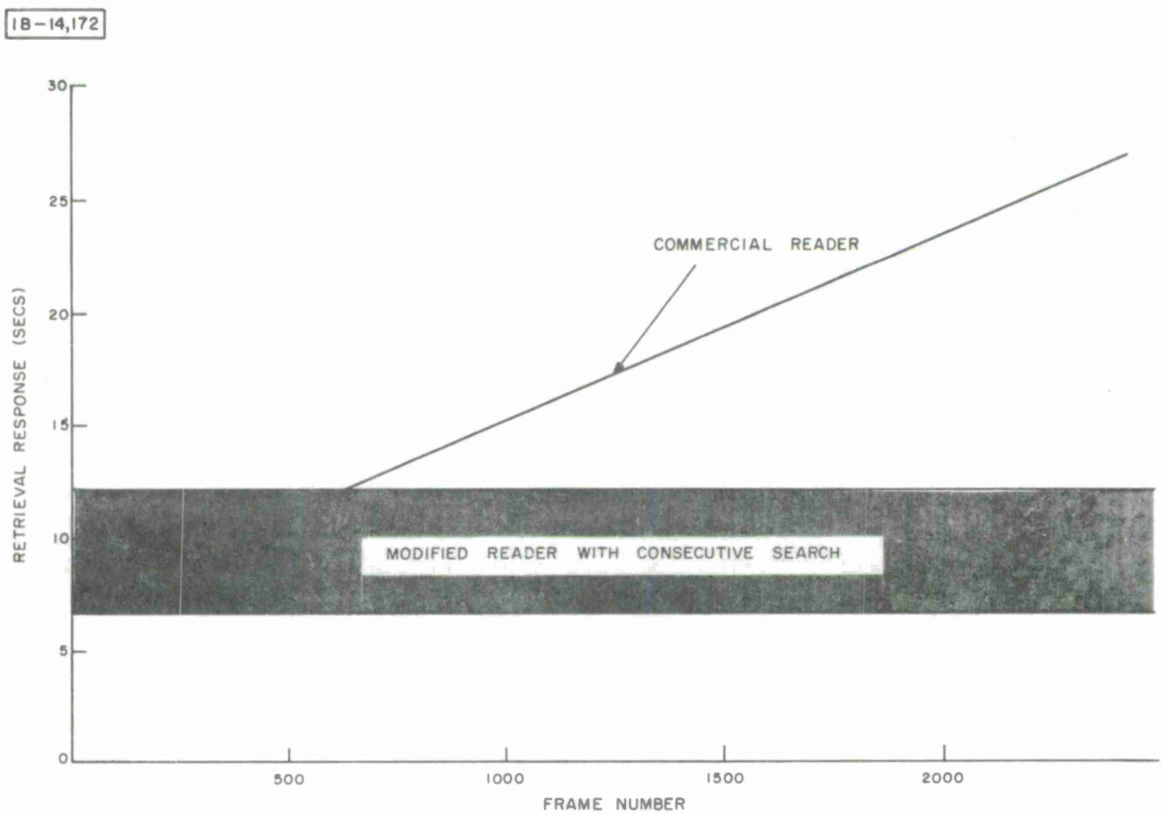

Figure 1. Advantage of Consecutive Search

A system was developed which has the capabilities of:

(1) information storage;

(2) information retrieval;

(3) information display; and

(4) rapid update of filmed data base.

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[1] "Test Results: Retrieval Response of Two Microfilm Reader/Retriever Equipment Configurations," George Barboza, The MITRE Corporation, W-5929, April 1963.

In order to exhibit the feasibility of the technique, a limited capability prototype was designed and fabricated. The basic design concept was to assemble a working prototype using commercially available hardware (see Appendix II) as much as possible.

The most significant accomplishment is the addition of the dynamic method of updating the filmed data base. It is the belief of the author that this concept of dynamic updating is indeed a worthwhile contribution to the state-of-the-art in microfilm information storage and retrieval.

SECTION III

DESIGN APPROACH

A study of the state-of-the-art in microfilm hardware[2] revealed that commercial equipment was available possessing many of the characteristics desirable in the prototype. Simplicity of design was achieved in the prototype by the procurement of a commercial 16-mm microfilm reader/ retriever and associated camera equipment (see Appendix II) for the preparation of the storage medium. The rotary camera equipment provided a high-speed device for filming data. The film drive mechanism and projection optics of the commercial reader were used in the prototype. A medium was developed which allowed magnetic storage of the dynamic information in addition to photographic storage of the static information (see Appendix B for definition of static and dynamic information). It was desirable to view the photographic information during the updating process. Thus, the magnetic read/write head was translated across the stationary storage element. Consecutive search logic decreases the retrieval response. Dynamic data entry is made via an input keyboard. An accessory display is used to view selectable portions of the update information and provides a means of visual error-check during data entry.

STORAGE ELEMENT

A single storage element was used to contain both the photographic and magnetic information. Registration problems associated with the search and transport of separate media were eliminated. The storage element selected for the prototype equipment was 100-foot reels of 16-mm unperforated microfilm

---

[2] "Preliminary Survey of Information Storage and Retrieval Equipment for Command and Control Systems," George Barboza, The MITRE Corporation, W-4841, March 1962.

(see Figure 2 for the physical format of the storage element). Document images are stored on the lower portion of the film at a linear reduction ratio of 24 to 1. The upper section is reserved for the 130-mil wide magnetic strip which is applied after processing of the exposed film. Individual magazine elements, with a capacity of storing 100 feet (≈2450 8.5 by 11 inch reduced images) of processed film are utilized to contain the film reels.

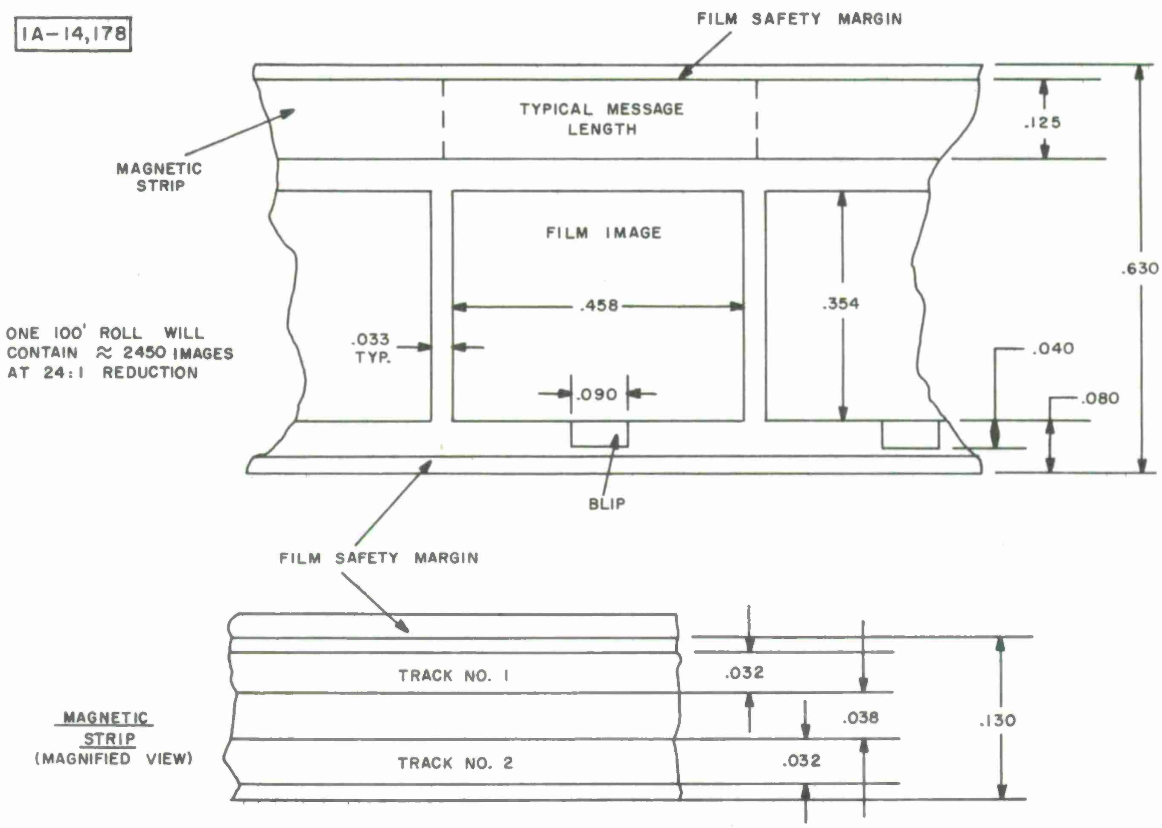


Figure 2. Storage Element Format

A blip is automatically affixed on the film under each document image during filming of the data base. This blip (Figure 2) is used for two purposes. Automatic retrieval is accomplished by simply counting the number of blips on the film. A photodiode device senses and counts these blips as the film is transported by the field of view of the sensor. The blip also provides a means of centering the retrieved image for display on the reader screen.

After the 100-foot reel of film was exposed and processed (developed) the film was sent to an outside contractor for the depositing of the magnetic strip. Several inquiries revealed that only a single company was equipped to perform this operation and the product received was of audio-tape quality. Later, tests revealed that the quality (approximately 70 percent reliability of successful read/write) did not approach a level required for digital application. Further development is required in this area to produce a good, reliable (no bit dropout) magnetic storage element.

Two tracks were sufficient to contain the update information. One of the tracks was used to contain the binary coded data and the other utilized as a timing synchronizer (clock track). Each information bit has a corresponding timing bit to clock the information from the magnetic strip. A clock rate of 12.5 kc and a head-to-tape relative velocity of approximately 20 ips, resulted in a nominal packing density of 625 bits/inch/track. The 128 information bits plus a 16-bit SOM (Start of Message) code are thus stored on approximately half (0.230 in.) of the available (0.500 in.) image message length.

READER/RETRIEVER MODULE

The reader/retriever module houses the film transport motors, film drive and guide, the magnetic head translation mechanism and the projection optics for magnification and rear-projection of the retrieved image on the built-in screen.

Magnetic Head Translation Mechanism

A constant-velocity head translation mechanism was designed, fabricated and integrated into the reader/retriever module. A detailed description of the analysis and design of the head translation mechanism is included in Section V.

CONTROL PANEL AND DISPLAY MODULE

A control panel and display module was designed and fabricated to allow keyboard entry of the update information. This module included a four-character, in-line, numeric-only display to allow viewing of selectable portions of the update information. Controls were included to perform other required functions such as (1) power on, (2) read, (3) write, (4) clear register, (5) frame/word mode select, (6) data entry, etc. These functions are discussed in more detail later in this report.

LOGIC AND POWER MODULE

The logic and power module was designed, fabricated and mounted in a standard size relay rack. This module contains the necessary logic and storage registers to perform the frame search and dynamic data manipulations. The decision-making processes are accomplished in this module which serves as the central control for the entire system. Commercial power supplies are also housed in this module.

SECTION IV

UPDATE CAPABILITY

As previously mentioned, the prototype was constructed to demonstrate the feasibility of the concept of dynamic updating rather than to perform any specific operational assignment. For this reason, the system capability and accompanying complexity was established at corresponding levels. Appropriately then, numerical update characters were all that was required. This allowed (1) simplicity in the design of the accessory display, (2) minimum size of the storage registers, (3) simple decoders, (4) a small, input keyboard device and in general a small, low cost prototype that would accomplish its design objectives.

Data is stored in a binary coded decimal (BCD) format. A capacity of 32 numerical characters of changeable information was assigned to each microfilm image. This means that, in addition to the static information stored photographically, there are 32 characters of magnetic (dynamic) information associated with every image or $32 \times 4 = 128$ bits. The total magnetic storage capacity of one 100-foot reel is then in excess of 300, 000 bits.

A variable word length assignment was included in the design of the present prototype. The 32 characters associated with each image can be selected in three different word lengths (i. e., there are three modes of word assignment operation). Of the 32 characters in any of the three modes, the first four characters are assigned for use as the frame number designator. The 28 characters remaining can be divided in one of the following addressable forms:

(1) 7 words of 4 characters each;

(2) 14 words of 2 characters each; and

(3) 28 words of 1 character each.

Any one of these three modes is selectable at the control panel by the 3-position word mode selector. Figure 10 shows the variable word length options.

SECTION V

ANALYSIS AND DESIGN OF THE MAGNETIC HEAD TRANSLATION MECHANISM

When the concept of magnetic updating of a microfilmed data base was first explored, there existed some doubt as to the amount of complexity involved in attempting to accomplish the mechanical inversion of the magnetic tape/head relation. A prime design requirement was to have the tape element fixed while translating the magnetic head across the tape element. Display of the photographically stored image was desirable during the update process. A decision was made to build a simple device with a one-track magnetic head which would accomplish this task. This mechanism would serve a twofold purpose:

(1) Exhibit the simplicity of the required mechanical design, and

(2) Demonstrate that the concept (i. e., translating the head across the tape) was a feasible approach.

A basic slider crank mechanism was selected for analysis of the velocity distribution because of its geometrical and physical simplicity. The basic geometry of the slider crank mechanism is shown in Figure 3. For reasons described later in this section, this configuration was not used in the final version.

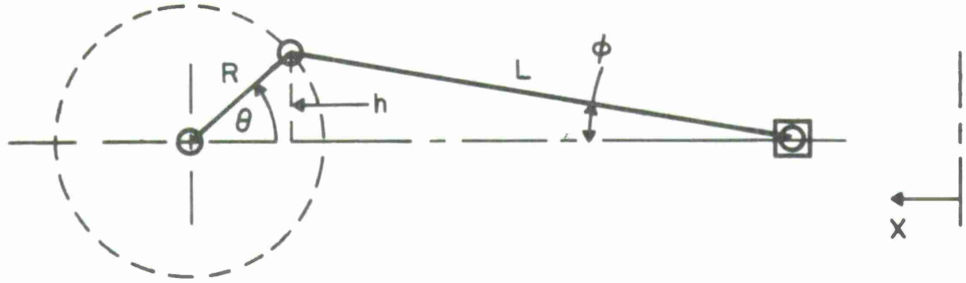
ANALYSIS OF THE SLIDER CRANK MECHANISM

Referring now to the geometry of the slider crank mechanism in Figure 3, we see that the expression for the slider displacement is:

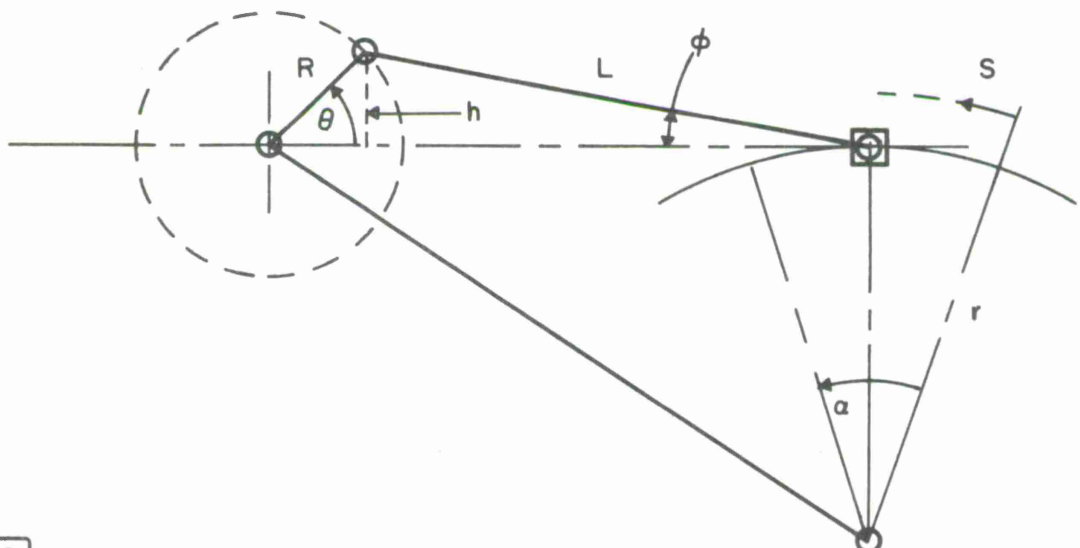
$$X = R + L - R\cos\theta - L\cos\phi \quad . \tag{1}$$

Rearranging the right side of Equation (1) we have:

$$X = R(1 - \cos\theta) + L(1 - \cos\phi) \quad . \tag{2}$$



SLIDER CRANK LINKAGE



FOUR BAR LINKAGE

1A-14,168

Figure 3. Geometrical Arrangement

We would now like to relate the two variables θ and ϕ in order to eliminate ϕ as a parameter because it is the crank angle θ which is of primary concern. The geometry of the slider crank in Figure 3 indicates that

$$h = R \sin \theta = L \sin \phi \tag{3}$$

or

$$\sin \theta = \frac{R}{L} \sin \theta \ . \tag{4}$$

Squaring both sides of Equation (4) we have

$$\sin^2 \phi = \frac{R^2}{L^2} \sin^2 \theta \ . \tag{5}$$

Multiplying both sides of Equation (5) by (-1) and then adding 1 to both sides we have

$$1 - \sin^2 \phi = 1 - \frac{R^2}{L^2} \sin^2 \theta \ . \tag{6}$$

The intent here is to eliminate ϕ by expressing it as a function of $\theta = \theta(t)$ which is a function of time. This parameter elimination is essential since the ultimate aim is to differentiate the slider displacement X with respect to time to obtain expressions for the velocity and acceleration of the slider block.

Now from the trigonometric identity

$$\cos^2 \phi = 1 - \sin^2 \phi \ , \tag{7}$$

we see that Equation (6) becomes

$$\cos^2 \phi = 1 - \sin^2 \phi = 1 - \frac{R^2}{L^2} \sin^2 \theta \ . \tag{8}$$

Taking the positive square root of Equation (8) we see that

$$\cos \phi = \sqrt{1 - \sin^2 \phi} = \sqrt{1 - \frac{R^2}{L^2} \sin^2 \theta} \quad . \tag{9}$$

Multiplying Equation (9) by (-1) and adding 1 to both sides we have

$$(1 - \cos \phi) = 1 - \sqrt{1 - \frac{R^2}{L^2} \sin^2 \theta} \quad . \tag{10}$$

Equation (10) has exactly the same form as the last term on the right side of Equation (2). Substitution of Equation (10) in Equation (2) yields

$$X = R\,(1 - \cos \theta) + L\,(1 - \cos \phi) = R\,(1 - \cos \theta) +$$

$$L \left\{ 1 - \sqrt{1 - \frac{R^2}{L^2} \sin^2 \theta} \right\} , \tag{11}$$

or

$$X = R\,(1 - \cos \theta) + L \left\{ 1 - \sqrt{1 - \frac{R^2}{L^2} \sin^2 \theta} \right\} = X\,(\theta) \; . \tag{12}$$

Equation (12) is now an expression for the displacement X in terms of the parameter θ, which, as previously stated, is a function of time (i. e., $\theta = \theta(t)$). Attempting to differentiate Equation (12) to obtain expressions for velocity and acceleration will result in undue complexity. Therefore a simplification of this equation is desirable.

Application of the binomial theorem to the expression under the radical on the right side of Equation (12) gives the binomial series form

$$\left[1 - \left(\frac{R}{L}\sin\theta\right)^2\right]^{\frac{1}{2}} = 1 - \frac{1}{2}\left(\frac{R}{L}\sin\theta\right)^2 - \frac{1}{2.4}\left(\frac{R}{L}\sin\theta\right)^4 - \frac{1.3}{2.4.6}\left(\frac{R}{L}\sin\theta\right)^6 - \ldots$$

Since, in our case, $R/L < 1$ and $\sin\theta \leq 1$, the terms beyond the square may be dropped without appreciable error (i. e., series converges rapidly). The expression for the slider displacement becomes

$$X = R(1 - \cos\theta) + \frac{R^2}{2L}\sin^2\theta , \tag{13}$$

where R, L are physical constants which are determined by the geometry (i. e., R, L do not vary with time). The expression for the slider velocity is simply the derivative of Equation (13) with respect to time. Use of the derivative of a function-of-a-function $\left(\text{i. e., } X = X\left[\theta(t)\right]\right)$ rule we have

$$V = \frac{dX}{dt} = \frac{dX}{d\theta}\frac{d\theta}{dt} ,$$

where $d\theta/dt = w$ is the angular velocity of the crank arm, R, and is constant for our application. Therefore:

$$V = \frac{dX}{dt} = R\sin\theta\frac{d\theta}{dt} + \frac{1}{2}\frac{R^2}{L}(2\sin\theta\cos\theta)\frac{d\theta}{dt} . \tag{14}$$

Collecting similar terms and simplifying Equation (14) we get

$$V = \frac{dX}{dt} = Rw\left(\sin\theta + \frac{1}{2}\frac{R}{L}\sin 2\theta\right) . \tag{15}$$

In Equation (15) we have used $d\theta/dt = w$ and the trigonometric identity $2 \sin\theta \cos\theta = \sin 2\theta$. The expression for the acceleration is obtained by differentiation of Equation (15) to obtain:

$$A = \frac{dV}{dt} = RW \left[\cos\theta \frac{d\theta}{dt} + \frac{R}{2L} (2 \cos 2\theta) \frac{d\theta}{dt} \right],$$

or, since $w = d\theta/dt$,

$$A = Rw^2 \left(\cos\theta + \frac{R}{L} \cos 2\theta \right). \tag{16}$$

The following, rewritten to summarize, are the simplest forms for the displacement, velocity and acceleration of the slider block in the geometry of the slider crank mechanism shown in Figure 3:

$$\begin{aligned} X &= R(1 - \cos\theta) + \frac{R^2}{2L} \sin^2\theta , \\ V &= \frac{dX}{dt} = Rw \left(\sin\theta + \frac{R}{2L} \sin 2\theta \right) , \text{ and} \\ A &= Rw^2 \left(\cos\theta + \frac{R}{L} \cos 2\theta \right). \end{aligned} \tag{17}$$

On the basis of this analysis, the slider crank mechanism was fabricated and used to translate a single-track magnetic head across a magnetic strip on a stationary 16-mm film. Output signals from the head were amplified and displayed on a scope. Results of the tests were so satisfactory that the feasibility of concept was readily established.

A commercial microfilm reader was then procured. The physical integration of the magnetic head mechanism with the film guide necessitated a modification of the geometry of the head translation mechanism. This new geometrical arrangement is shown in Figure 3 (lower section). Comparison of the slider crank geometry with that of the new four-bar linkage indicated that the slider crank was really a special case of the four-bar linkage. This can be seen mathematically if, in the four-bar geometry, we allow "r" to approach infinity. Indications were that instead of a completely new analysis, the one previously derived could be extended to describe the four-bar geometry. This was indeed the case as is shown in the following section.

EXTENSION OF THE ANALYSIS TO THE FOUR-BAR GEOMETRY

From Figure 3 (lower section) we see that

$$S = r\alpha \tag{18}$$

and

$$\frac{X}{2} = r \tan\frac{\alpha}{2} \quad . \tag{19}$$

The explicit expression for the variable α is, from Equation (19),

$$\alpha = 2 \tan^{-1}\left(\frac{X}{2r}\right) \quad . \tag{20}$$

Substituting Equation (20) in Equation (18) we have

$$\frac{S}{2r} = \tan^{-1}\left(\frac{X}{2r}\right) \quad . \tag{21}$$

We are primarily interested in the velocity profile or more specifically the velocity along the arc S as a function of time. Thus, we need to determine the relationship between the horizontal velocity dX/dt and the arc length velocity dS/dt. This is accomplished by differentiation of Equation (21) with respect to time, keeping in mind that r is a geometrical notion, constant with respect to time. Performing this operation we get

$$\frac{dS}{dt} = \frac{\frac{dx}{dt}}{1 + \left(\frac{x}{2r}\right)^2} = \frac{V}{1 + \left(\frac{x}{2r}\right)^2} \quad . \tag{22}$$

Rewriting Equation (21) in terms of S we have:

$$S = 2r \tan^{-1}\left(\frac{X}{2r}\right) \quad . \tag{23}$$

Substituting the expression for X from Equation (17) into Equation (23) we get

$$S = 2r \tan^{-1}\left[\frac{R}{2r}(1 - \cos\theta) + \frac{R^2}{4rL}\sin^2\theta\right] \quad . \tag{24}$$

Since we desire the arc length S as a function of time, we proceed as follows. As we recall, the term $w = d\theta/dt$ appearing in Equation (17) is not a function of time; i. e., $w = d\theta/dt$ is constant. If we integrate $d\theta = wdt$ we get $\theta = wt + c$, where c is a constant of integration. Using the condition $\theta = 0$ at $t = 0$ we find that $c = 0$, so that

$$\theta = wt, \ w \text{ constant} \ . \tag{25}$$

Substitution of Equation (25) into Equation (24) yields the desired expression for the arc length as a function of time:

$$S = 2r \tan^{-1}\left[\frac{R}{2r}(1 - \cos wt) + \frac{R^2}{4rL}\sin^2 wt\right] . \tag{26}$$

Substitution of Equation (25) into Equation (17) yields:

$$\left.\begin{aligned} X &= R(1 - \cos wt) + \frac{R^2}{2L}\sin^2 wt \ , \\ V &= \frac{dX}{dt} = Rw\left(\sin wt + \frac{R}{2L}\sin 2wt\right) . \end{aligned}\right\} \tag{27}$$

If we now substitute Equation (27) into Equation (22), we have the complex expression for the velocity dS/dt as a function of time:

$$\frac{dS}{dt} = \frac{Rw\left(\sin wt + \frac{R}{2L}\sin 2\,wt\right)}{1 + \frac{1}{4r^2}\left[R\,(1 - \cos wt) + \frac{R^2}{2L}\sin^2 wt\right]^2} \tag{28}$$

In summary then, we have extended the analysis of the slider block geometry to include the four-bar geometry. This extension is formalized by the parametric equations.

$$X = R\,(1 - \cos wt) + \frac{R^2}{2L}\sin^2 wt\ , \tag{29}$$

$$\frac{dX}{dt} = Rw\left(\sin wt + \frac{R}{2L}\sin 2\,wt\right)\ , \tag{30}$$

$\Big\}$ Slider Crank Mechanism

$$S = 2r\,\tan^{-1}\left[\frac{R}{2r}\,(1 - \cos wt) + \frac{R^2}{4rL}\sin^2 wt\right]\ , \tag{31}$$

$$\frac{dS}{dt} = \frac{Rw\left(\sin wt + \frac{R}{2L}\sin 2\,wt\right)}{1 + \frac{1}{4r^2}\left[R(1 - \cos wt) + \frac{R^2}{2L}\sin^2 wt\right]^2}\ , \tag{32}$$

$\Big\}$ Four-Bar Mechanism

where R, $w = d\theta/dt$, r, L are constants.

The displacement function (Equation 29) is shown graphically in Figure 4. The velocity profile as a function of time (Equation 30) is shown in Figure 5. Since Equations (29) and (30) are a pair of parametric equations in the variable t it is possible to obtain a functional relationship between the velocity and the displacement. This relationship is shown in Figure 6.

Figures 4 through 6 also exhibit the same properties for the four-bar linkage.

Finally, interesting comparisons can be made between the above relationships. Equations (29) through (32) are decidedly different in form and the geometry of the two mechanisms is dissimilar. It is interesting to note that the comparisons shown in Figures 4, 5, and 6 bear striking similarity. This is not an unfortunate event and, in fact, a most desirable and planned occurrence.

At first sight one might expect that the geometry, shown in Figure 3, for the four-bar linkage, would not yield a constant velocity device. This is indeed a false notion as the following observation will verify.

Examination of the standard formats used in commercial microfilm hardware reveals that the normal pitch (distance between consecutive images) on 16-mm film is in the order of 0.50 inch. This means that the magnetic information pertaining to a single image will be stored on 0.50 inch of film. Select the required 0.50-inch travel from the available total head travel of 2^{+} inches in the following manner. Graphically determine what value of S corresponds to the maximum dS/dt. Translate 0.25 inch to the left and right of that value to get the required 0.50-inch head travel. Now determine the corresponding values of dS/dt for these values of S. If we follow this procedure in Figure 7 we see that the total velocity change is less than 5 percent of the maximum velocity over the range of 0.50 inch in S. A direct implication is that a 5-percent deviation in output signal from the magnetic head results due to velocity modulation. For our application this is a trivial change and, for all practical purposes, we have a constant velocity device.

MECHANICAL DESIGN

On the basis of the preceding analysis the final configuration for the head translation mechanism was selected. The basic geometry of the slider-crank was expanded upon to accomplish the required function.

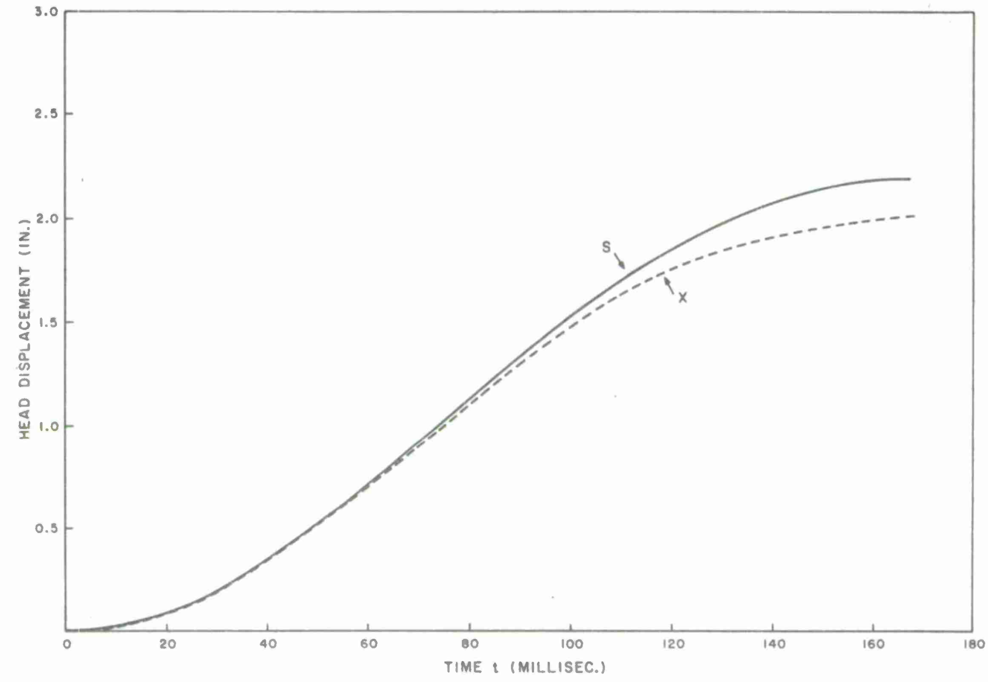


Figure 4. Comparison of Displacement Functions

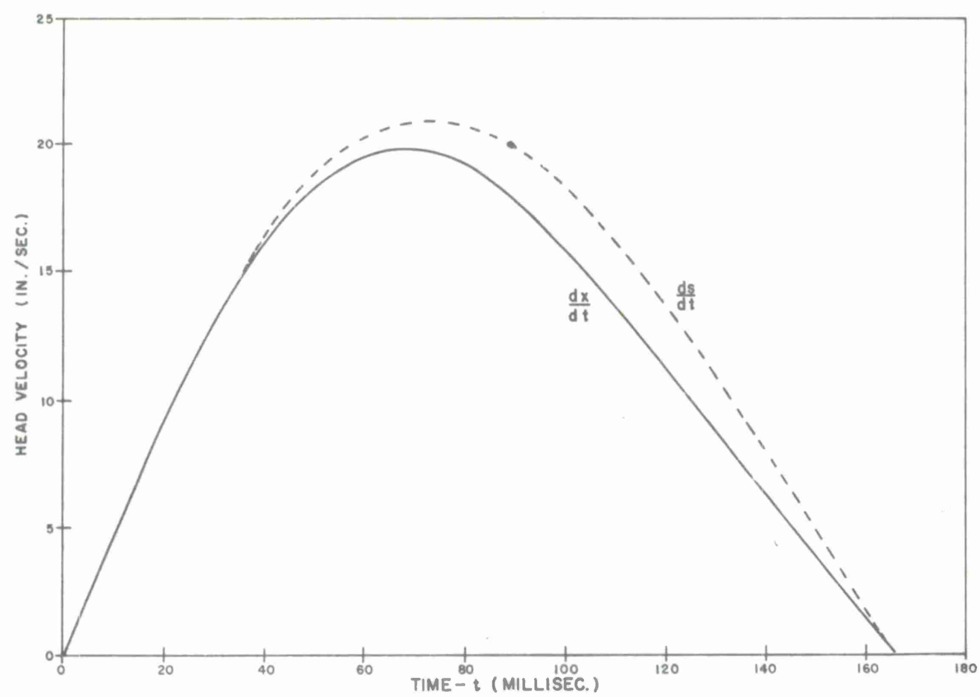


Figure 5. Comparison of Velocity Functions

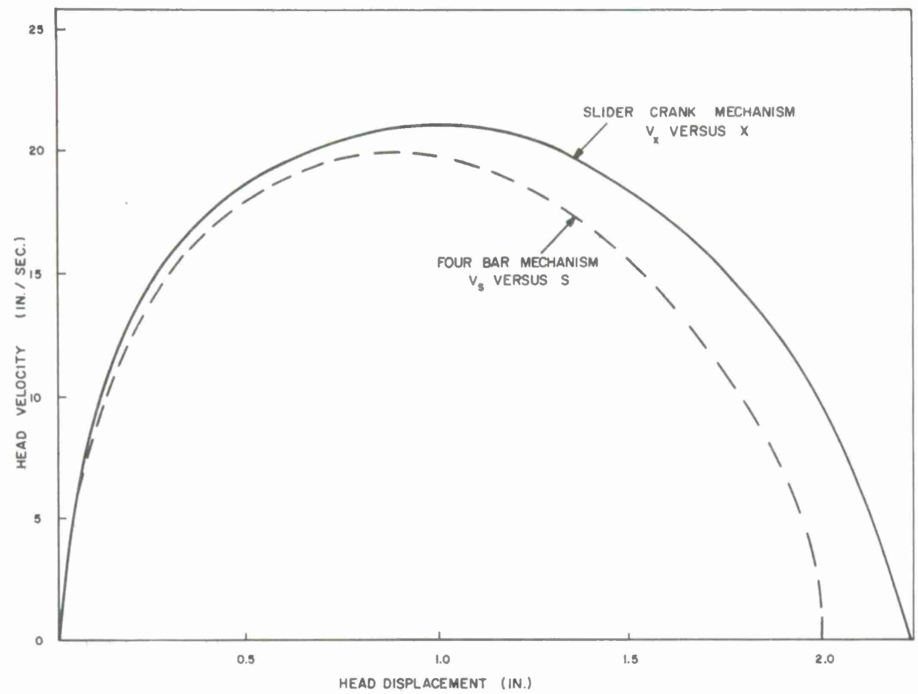


Figure 6. Comparison of Velocity/Displacement Profiles

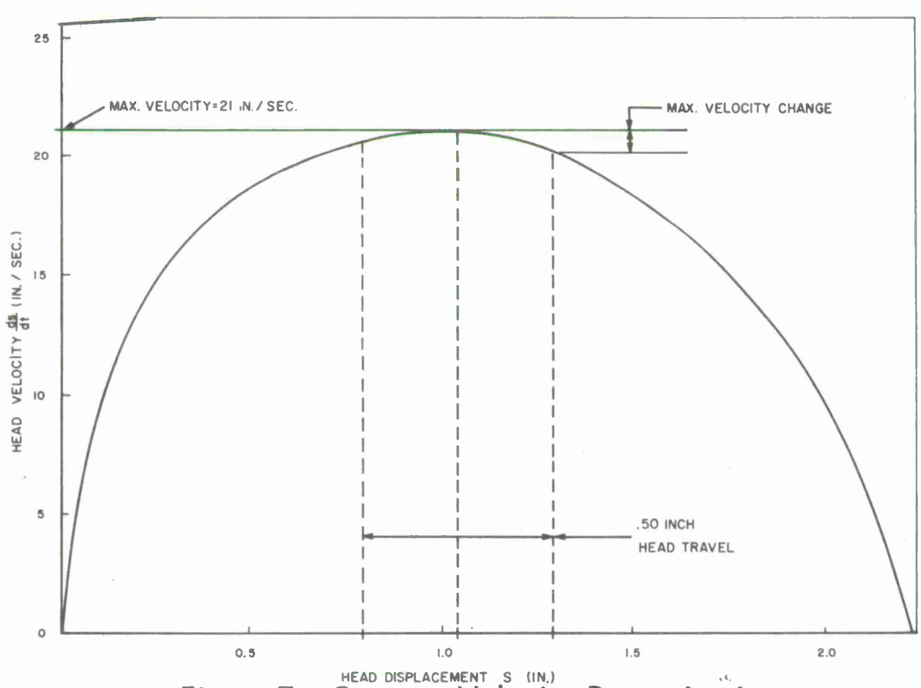


Figure 7. Constant Velocity Determination
Velocity/Displacement Profile – Four-Bar Mechanism

In general the design requirements consisted of two head translation motions: Insert and retract the magnetic head to and from the magnetic strip; and translate the magnetic head along the axis of the magnetic strip. Two main assemblies were required to accomplish these motions: the drive assembly and the recording head transport assembly.

Drive Assembly

The drive assembly provides a source of mechanical power to drive the recording head transport assembly. The basic components are:

(1) A-c motor and gear reduction;

(2) Magnetic clutch/brake;

(3) Variable dwell cam assembly; and

(4) Gear train.

The motor and gear reduction units provide the necessary torque and shaft speeds to translate the magnetic head at a nominal 20 ips velocity. A-c power to the drive motor was originally wired into the reader/ retriever so that the drive motor was running whenever a film magazine was inserted. Later a shutoff switch was added.

Under control of one of the variable dwell cams, the magnetic clutch engages or disengages the driving torque. A single cycle control provides one-and-only-one pass of the magnetic head by the magnetic strip on the film. Another variable dwell cam controls power to the head insertion/ retraction solenoid. The solenoid inserts the magnetic head onto the microfilm magnetic strip during the forward stroke of the recording head transport assembly.

During the reverse stroke, solenoid power is cut off and the magnetic head is retracted under spring tension.

Recording Head Transport Assembly

The recording head transport assembly is the mechanism required to translate the magnetic head. The basic components are:

(1) Magnetic read/write head;

(2) Head insertion/retraction solenoid; and

(3) Mechanical linkage to mount and traverse the head.

Reader/Retriever Modifications

Certain modifications were required in the reader/retriever in order to accomplish the mechanical integration of the magnetic head translation mechanism with the commercial reader/retriever. These modifications were mainly concerned with the rework and redesign of the commercial film guide but also included changes in the reader/retriever console.

Plug-In Unit Subrack Assembly

The printed circuit logic cards used to construct the required logical functions were housed in light-weight aluminum subracks. Taper pin connectors were used throughout the fabrication of the logic module. In this manner, ease of fabrication and modular construction was obtained in the prototype equipment.

SECTION VI

FUNCTIONAL DESCRIPTION OF THE PROTOTYPE

GENERAL

The basic logical functions performed by the prototype may be divided into two main categories: Automatic frame search mode and information update mode.

Simplified functional analogs of these categories are presented in Figures 8 and 9. However, the detailed logic workings are appreciably different in engineering detail, than is indicated in these analogs. Since the purpose of this section is to clarify the functional capability, these analogs were derived to describe this capability in the simplest manner possible. Every effort was made to avoid masking the explanation with undue complexity of detail.

A consecutive search capability was designed and built into the prototype to improve the retrieval response times associated with the forward-only search technique which was used in the commercial reader/retriever procured. Consecutive search is defined as the capability to store the present position or frame number location on the film reel and search in either direction (i. e. , forward or reverse). The logical flow involved in accomplishing this consecutive search level of capability is shown in Figure 8. The advantages of consecutive search over forward-only search is shown in Figure 1.

AUTOMATIC FRAME SEARCH MODE

The automatic frame search mode is selected at the control panel by depression of the button labeled FRAME. When this mode is selected, the keyboard shift register is conditioned to receive frame number inputs from the 10-button input keyboard. As shown in Figure 8, the keyboard shift register is used in the automatic frame search mode to receive and temporarily store the frame number request entered via the input keyboard. An accessory display

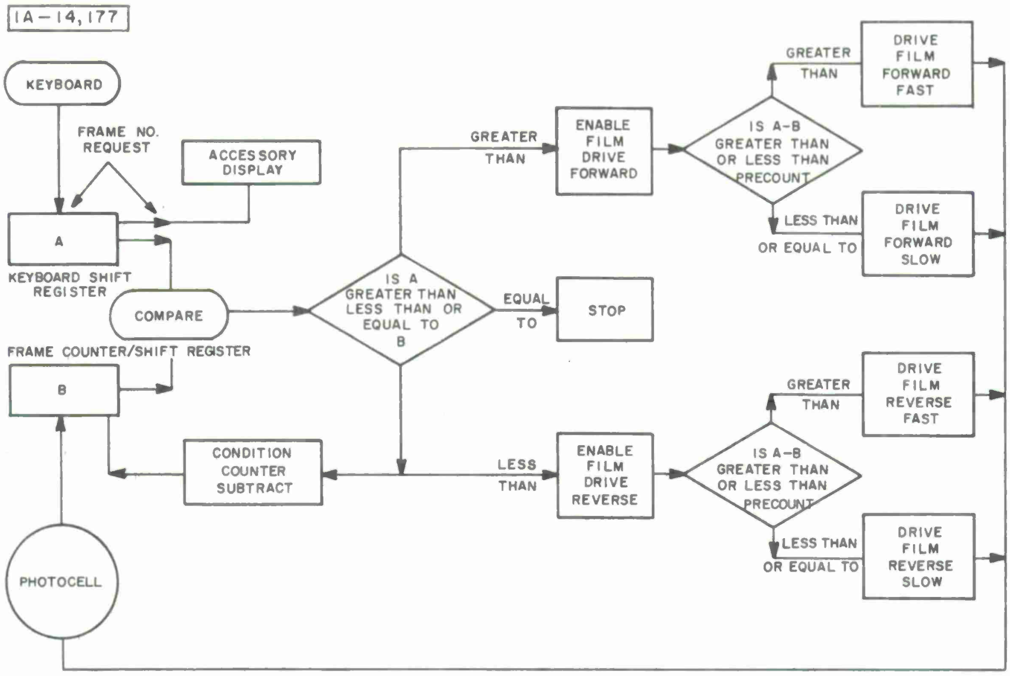


Figure 8. Simplified Logical Flow-Frame Search Mode

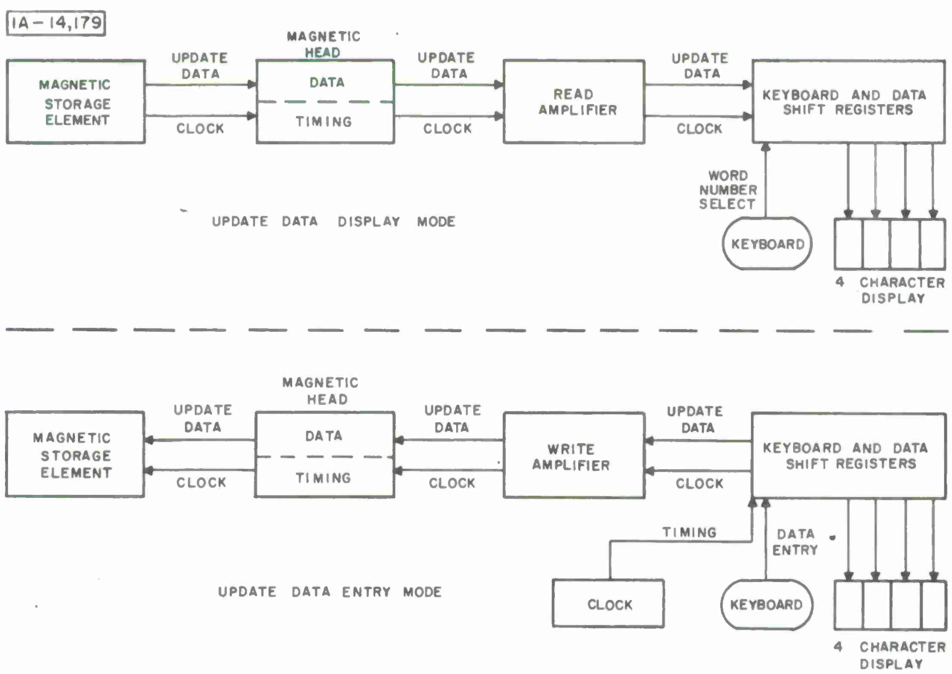


Figure 9. Simplified Logical Flow-Update Entry/Readout

device (4 character numeric in-line) is used in the automatic frame search mode to provide a visual display of the frame number request. This display verifies the correctness of the frame number input.

Depression of a key on the keyboard generates a 4-bit (8-4-2-1) binary code which corresponds uniquely to a numeric character (e.g., 5=0101). The last character of the mandatory 4-character input automatically starts the first stage comparison cycle. During this cycle the contents of the keyboard shift register are compared on a bit-by-bit basis with the contents of the frame counter/shift register. The frame counter/shift register contains a binary coded decimal indication of present frame location.

Logically, the first stage comparison determines the relative location of the desired frame number with respect to present position along the length of the film reel. If the film reel had just been loaded, the contents of the frame counter shift register is zero. If previous requests have been made, the contents of the frame counter shift register will be a direct indication of present position within the film reel.

Referring now to Figure 8, we see that one of three possible logical decisions is made as a result of the first stage comparison. Let us examine each of these possibilities in turn.

First Stage Compare — Greater Than

If the first stage comparison indicates that the desired frame number is numerically greater than the present position frame number, then an enable film drive forward command is initiated. Since film drive is accomplished by two reversible drive motors (i.e., a high and a low speed) a logical decision is now required to select which of these is activated. This function is accomplished in the second stage comparison (Figure 8).

If the desired frame number is greater than the present position frame number by a predetermined fixed amount, called the precount, then a drive film forward fast command is initiated. This command causes power to be applied to the high speed motor and the film begins to be driven forward at high speed (600 fpm).

If the second stage comparison yields the result that the desired frame number is less than or equal to the precount, then a drive film forward slow command is initiated. This command causes power to be applied to the low speed motor and the film begins to move forward at low speed (10 fpm).

In either of the above cases the film is now moving forward, causing the image blips (see Figure 2) to be sensed by a photocell device. As each blip is sensed by the photocell device a pulse is generated which adds one numerically to the contents of the frame counter shift register. The first stage comparison cycle is repeated as previously described. If this first stage compare still results in a "greater than" then the second stage comparison decides whether to continue driving at high speed forward or change to low speed forward. This process continues in a cyclic fashion with the photocell increasing the frame counter/shift register by one each and every time an image blip is sensed.

Ultimately, the cycle terminates with an "equal to" comparison in the first stage compare. When this happens the enable film drive forward command is withdrawn and a stop command is initiated. The stop command activates the magnetic clutch/brake in the film drive mechanism and the microfilm reel stops at the desired frame number. As the film stops the requested image is automatically centered and rear-projected on the screen for display.

First Stage Compare — Less Than

If the first stage comparison (see Figure 8) indicates that the desired frame number is numerically less than the present position frame number, then an enable film drive reverse command is intiated. The photcell detects only the presence of a blip and cannot detect direction of film travel. For this reason then, a "less than" result in the first stage compare also gives rise to a condition counter subtract command. This command conditions the frame counter/shift register to subtract one numerically from its contents when a photocell pulse is received.

The second stage compare following an enable film drive reverse command is logically similar to that described in the "First Stage Compare-Greater Than" section. Basically, the difference is one of reversing the polarity of the film drive motor selected as a result of the second stage comparison.

Operationally, the prototype performs in a similar manner in both forward and reverse search. As mentioned above, the main difference being that the frame counter/shift register is adding in the forward search mode and subtracting in the reverse search mode. High-speed film drive is accomplished with the same drive motor with polarity of applied dc power governing the direction of drive determined by the first stage compare. The same applies to the low speed motor.

First Stage Compare — Equal To

If the first stage comparison indicates that the desired frame number is equal to the present position frame number then a stop command is initiated. Actually the stop command is initiated before any film motion takes place when there exists an "equal to" comparison in the first stage compare.

INFORMATION UPDATE MODE

General

Operationally, the update functional flow mode is selected at the control panel after the requested image is retrieved and positioned for display on the reader screen. Now that the desired film image has been retrieved there is no further need for storage of the frame number request in the keyboard shift register. In the automatic frame search mode the keyboard shift register was used to enter and compare frame number requests. After the requested image is retrieved, this register may be cleared and used for the update information. This time sharing of the register allows more efficient utilization and deletes the need of separate registers to perform both functions.

The same keyboard is also used in both the automatic frame search mode and the information update mode. Depression of the button labeled WORD at the control panel conditions the logic so that keyboard entries now correspond to designated word selection.

Variable Word Length Selection Structure

The designated word selection options are shown in Figure 10. Update data totaling 32 numeric characters per film image can be selected in either of three options. In all of the three options, the first four characters (Word Number 0) were assigned to the frame number in order to provide a means of verifying that the image retrieved was indeed the one requested. The remaining 28 character positions are used for data storage. Within these 28 characters the operator has the option of arranging the update data in any of three ways by simply turning the word mode selector at the control panel.

In the "7 x 4" mode, data may be entered into or selected for display from the keyboard shift register, in 7 words of 4 characters each. Correspondingly, the "14 x 2" mode and the "28 x 1" mode have 14 words of 2 characters each and 28 words of 1 character each, respectively.

During operation in the information update mode, the keyboard is used to accomplish two functions. The first of these is to select the word number (i. e., position in keyboard shift register) while the second function is to enter data in

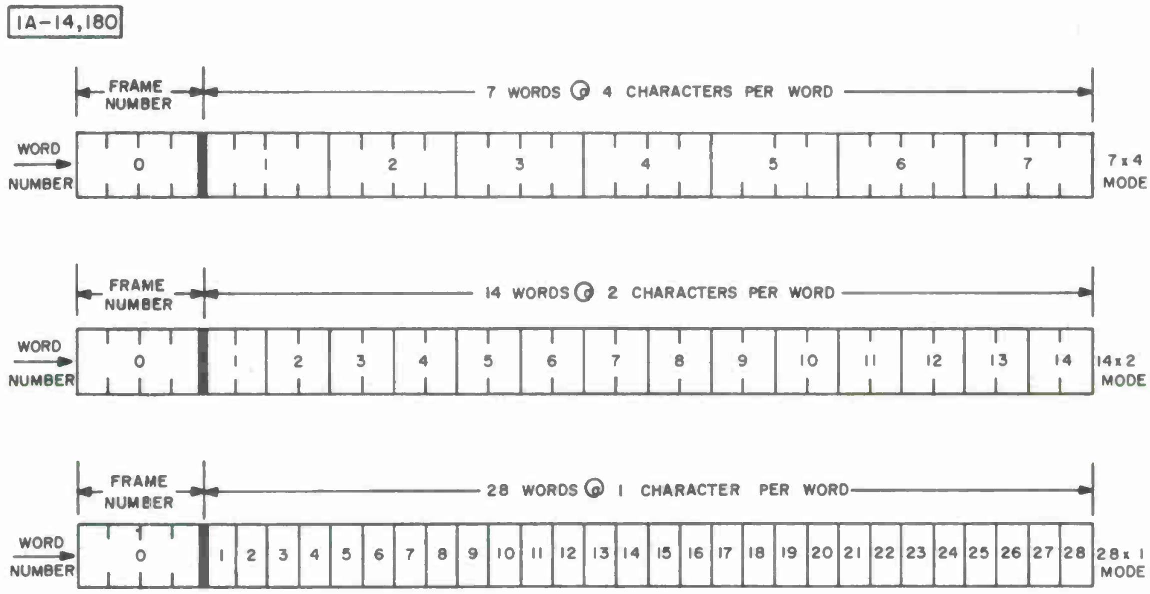


Figure 10. Variable Word Length Selection Structure - Keyboard Shift Register

that selected word number. The operator selects that word mode which corresponds to the format used in the initial preparation of the filmed data base.

Update Data Entry Mode

This mode of operation characterizes the manner in which data is entered (or changed) during the information update mode. As shown in Figure 9 (lower section) update data is entered into the keyboard shift register via the input keyboard. After completing the entry of all update data associated with the particular film image, the WRITE button on the control panel is depressed. This action causes the contents of the keyboard shift register to be written on the film magnetic strip. The output signals are amplified before being written on the magnetic storage element by the two-track head. A timing track is written synchronously to facilitate readback.

Update Data Display Mode

Upon completion of film image retrieval, data is read from the film magnetic strip by the two-track magnetic head. The data enters the keyboard shift register after signal amplification in the read amplifier. The contents of the keyboard shift register may now be selected by entering a word number into the control keyboard (see Figure 9 - upper section). Depending upon the word mode option (i. e., 7 x 4, 14 x 2, or 28 x 1) determined during data entry, groups of characters may be selected for display. For example, in the 7 x 4 mode, if word number 2 is desired the operator enters a 2 into the keyboard. The four characters associated with word 2 are then displayed on the accessory display.

If the operator then desires to change any or all of the characters in word 2 he clears the register by depressing the button labeled CLEAR K/B and re-enters the new information. To complete the update process the operator then rewrites the information (including changes) back onto the magnetic storage element. This operation is accomplished by depressing the WRITE button at the control panel.

SECTION VII

FUTURE DEVELOPMENT

Present plans include the fabrication of a console for operation in an airborne command post configuration. Redesign of some of the logic functions will be accomplished in addition to a reworking of the electro-mechanical and optical projection mechanisms. An integrated display will be added which allows simultaneous presentation of an entire image update message (32 numerical characters).

George Barboza

G. Barboza

APPENDIX I

PROTOTYPE LOGIC DESIGN

CONTROL PANEL

Logical schematics of the control panel are shown in Figure 11. Section VI of this document describes the logical functions associated with these schematics. The wiring details for the control panel are shown in Figure 12.

The pulse network schematic in Figure 13 is used to convert the signal levels from the keyboard to pulse outputs.

INDICATOR AMPLIFIERS

The indicator amplifier schematics shown in Figures 14 and 15 are used to drive the incandescent lamps which indicate the binary coded contents of the shift registers.

DISPLAY DECODERS AND DRIVERS

As shown in Figures 16 and 17, the display decoders convert the appropriate 1-2-4-8 code into a visual display of the representative numerical character.

KEYBOARD ENTRY CONTROL

The various modes of frame search, word select and data entry as described in Section VI, are shown in schematic form in Figure 18. This logic determines when a word request is completed and initiates an automatic sequence of events which circulates the desired word into the keyboard shift register.

SHIFT PULSE DRIVER

As shown in Figure 19, the shift pulse driver schematic contains the logic required to generate the 16 shift pulses during the scan period. During this period of the frame search mode, the frame counter shift register contents and the keyboard shift register contents are compared.

KEYBOARD SHIFT REGISTER

Figure 20 shows that flip-flop building blocks are utilized to construct the 16-bit shift register required to temporarily store, shift, and compare the inputs from the keyboard. As described in Section VI, this register serves a dual purpose function by performing its operations during both the frame search mode and update mode.

FRAME COUNTER/SHIFT REGISTER

The frame counter/shift register functions are described in Section VI and shown in block diagram form in Figure 8. Essentially, the FC/SR stores the present frame location and counts up or down depending upon the output of the first stage comparison. The schematics for the frame counter/shift register are shown in Figures 21 through 24.

SYNCHRONIZATION AND CLOCKING

Figures 25 and 26 show the basis for clocking and proper pulse shape generation in order to provide synchronization of all the logical operations described.

FORWARD/REVERSE CONTROL

Figure 27 shows the schematic associated with the manually selected options of slow-speed film advance. These options are selected at the control panel by the buttons labeled FORWARD and REVERSE.

PRECOUNT CONTROL AND REGISTER

The precount control (see Figure 28 and 29) is used in conjunction with the precount register to provide a means of film speed transition in either the forward or reverse directions. At a predetermined interval of 56 frames before the requested frame, the film drive motors are switched from high to low speed. Then the precount register is counted down by photocell pulses and a film stop command is initiated when the contents of this register are zero.

SELECTOR CONTROL FOR EXTERNAL OPERATION

A means of switching to the operational control of the commercial Recordak logic is provided in the prototype for two reasons. The first of these is to provide a means of error isolation, and the second is to demonstrate the improvement in retrieval response attributable to the consecutive search capability. The schematic for this selection is shown in Figure 30.

WORD SELECTION CONTROL

Two functions, depending on whether data is being entered or selected for display, are shown in Figure 31.

If data is being entered, the word position into which the data is to be entered is selected at the keyboard. The data mode is then selected and update data entry is made via the keyboard.

If data is being selected for display, the appropriate word number is selected and the corresponding characters are shifted and displayed on the accessory display.

The functional operations pertaining to both these modes is described in Section VI.

SCAN COUNTING AND RESET

The logic associated with scan counter reset, word comparison, and scan counter is shown in Figure 32 and is self-explanatory.

READ/WRITE CONTROL

Figures 33 and 34 are the schematics associated with control and timing of the data-read/write function described in Section VI.

UPDATE DATA STORAGE

The schematic for the updatable data shift register is shown in Figure 35. As described earlier, this register provides a storage element for data to be written onto or read from the film strip. Data is always formatted or changed in the keyboard shift register and then transferred to the update data shift register in preparation for rewriting on the magnetic strip.

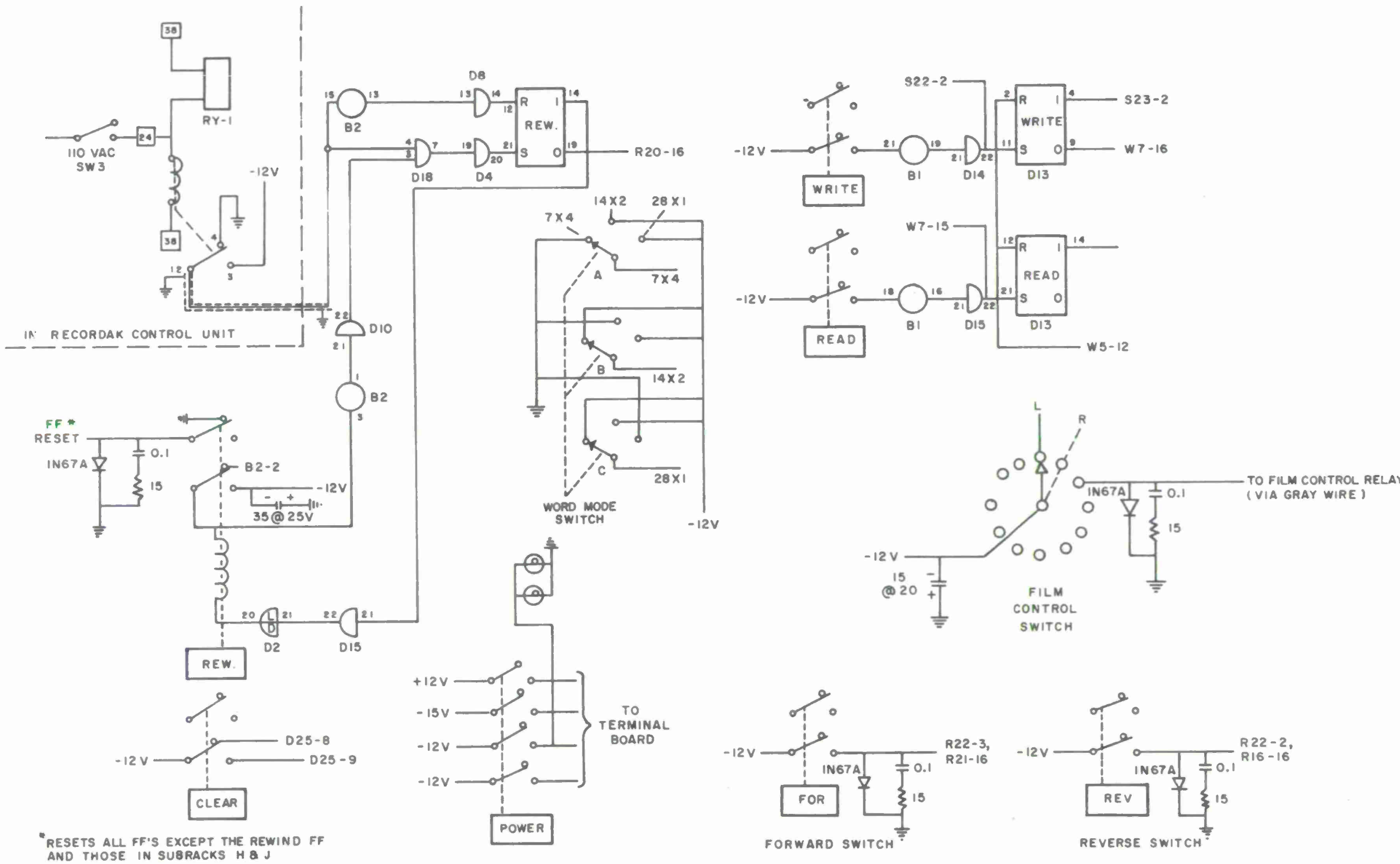


Figure 11. Control Panel Switches

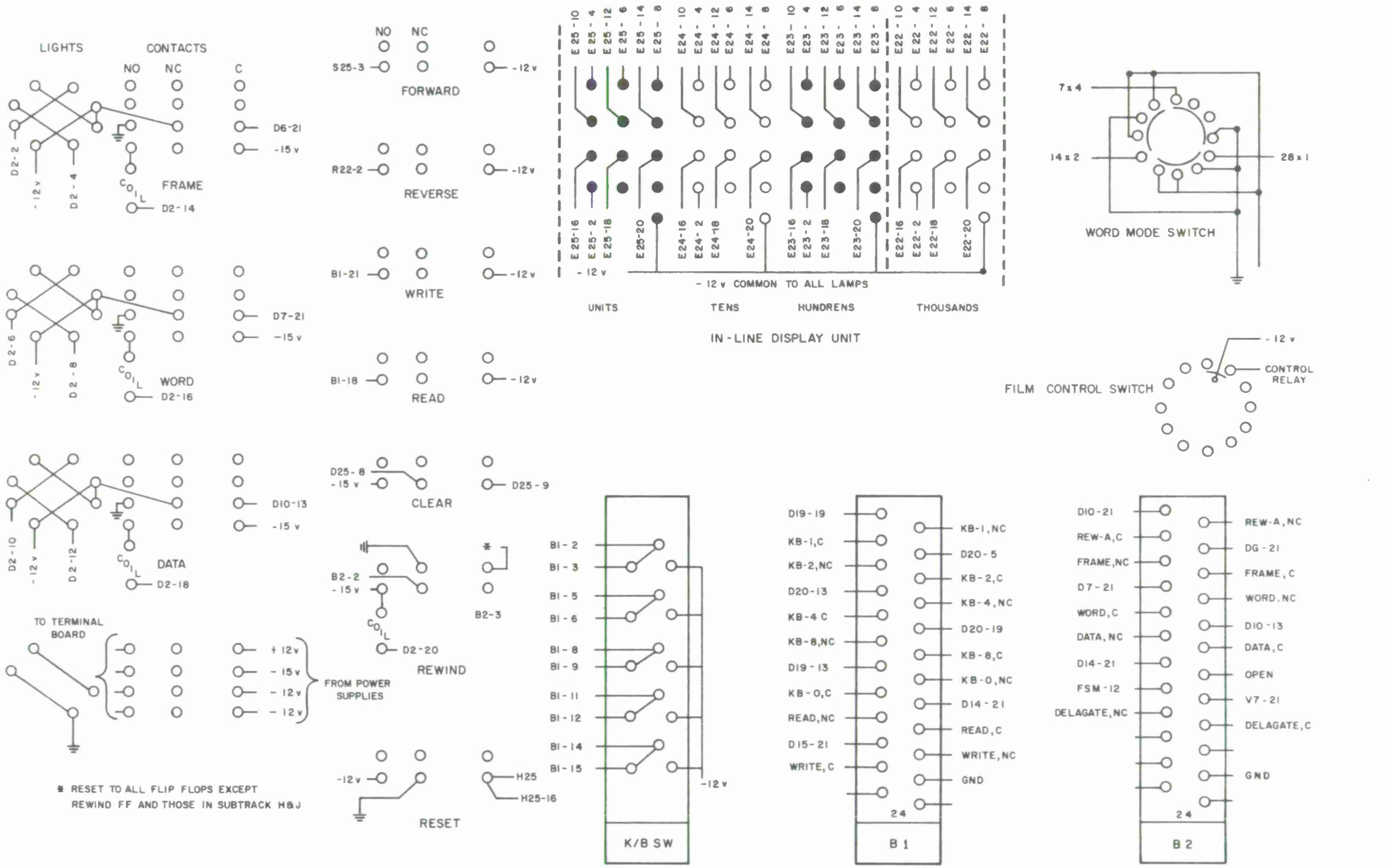


Figure 12. Control Panel Wiring Diagram

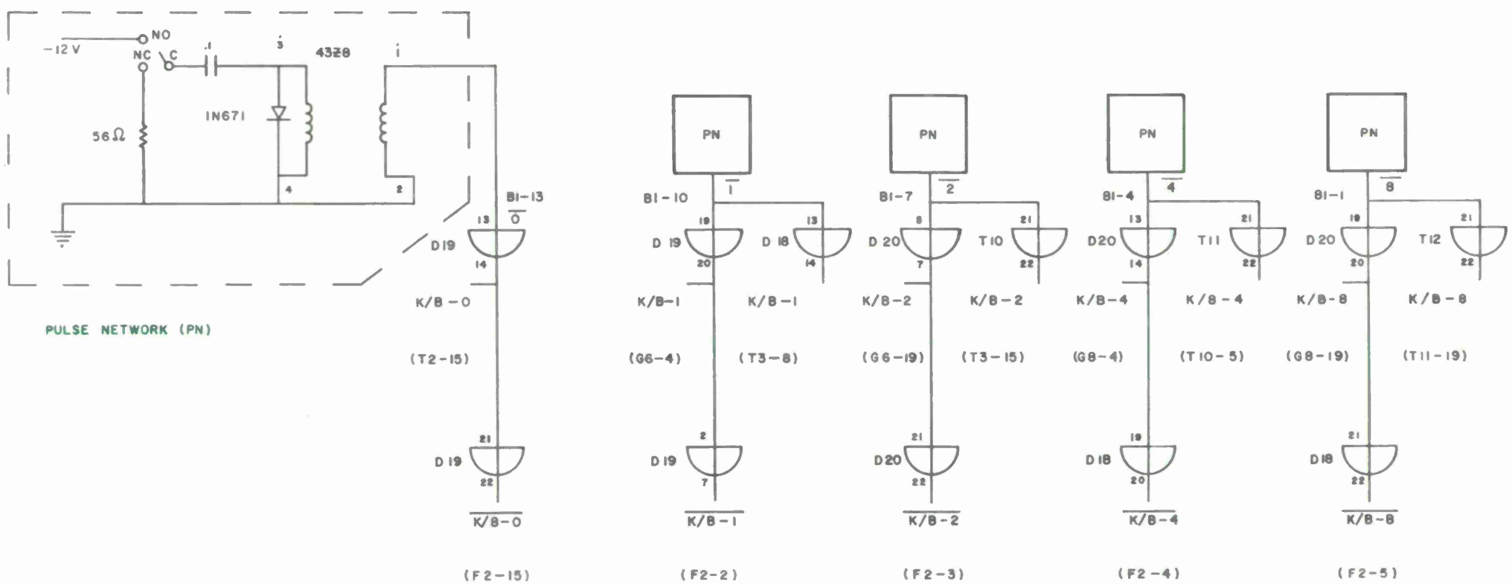


Figure 13. Pulse Network Schematic Diagram

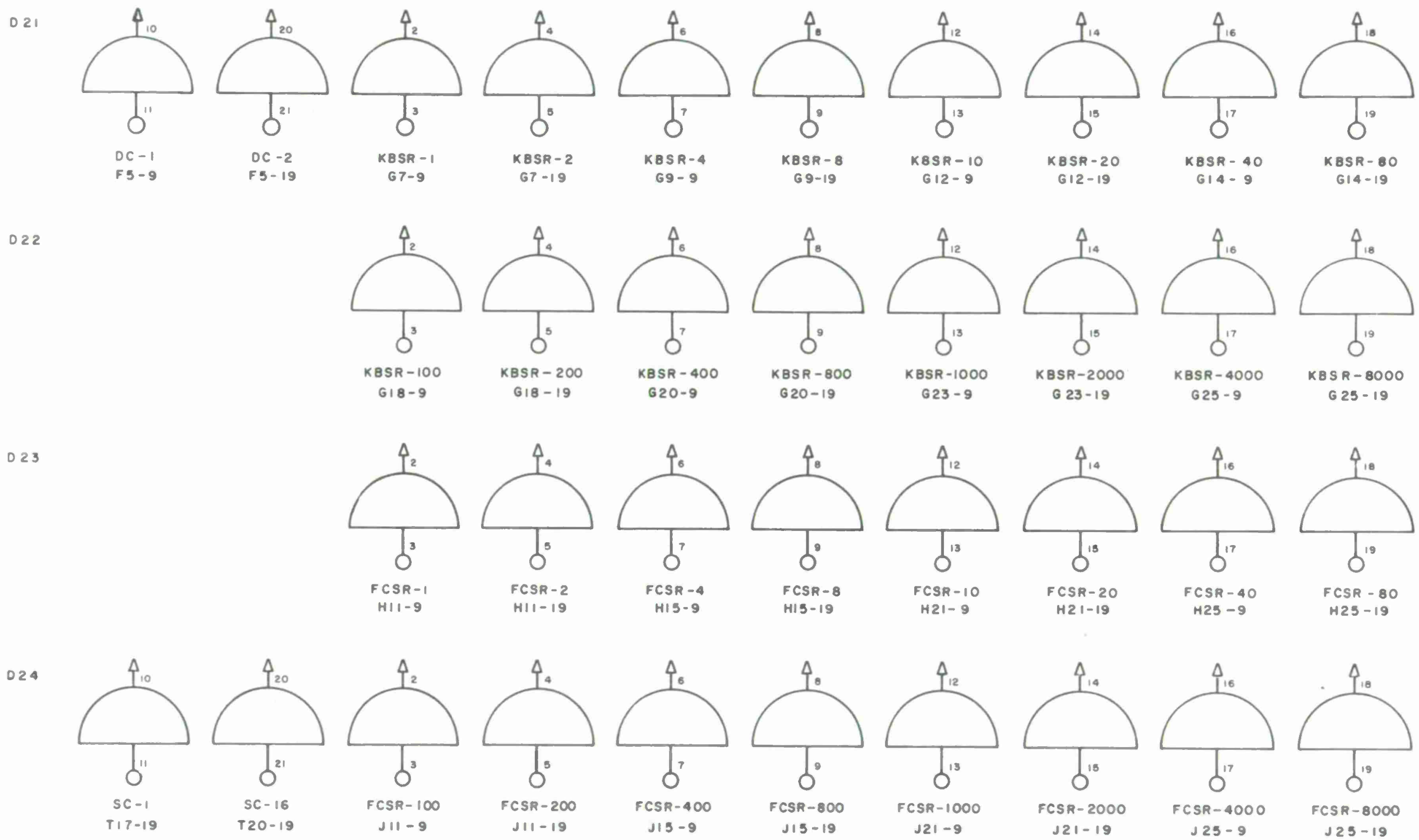


Figure 14. Indicator Amplifiers (Subrack A)

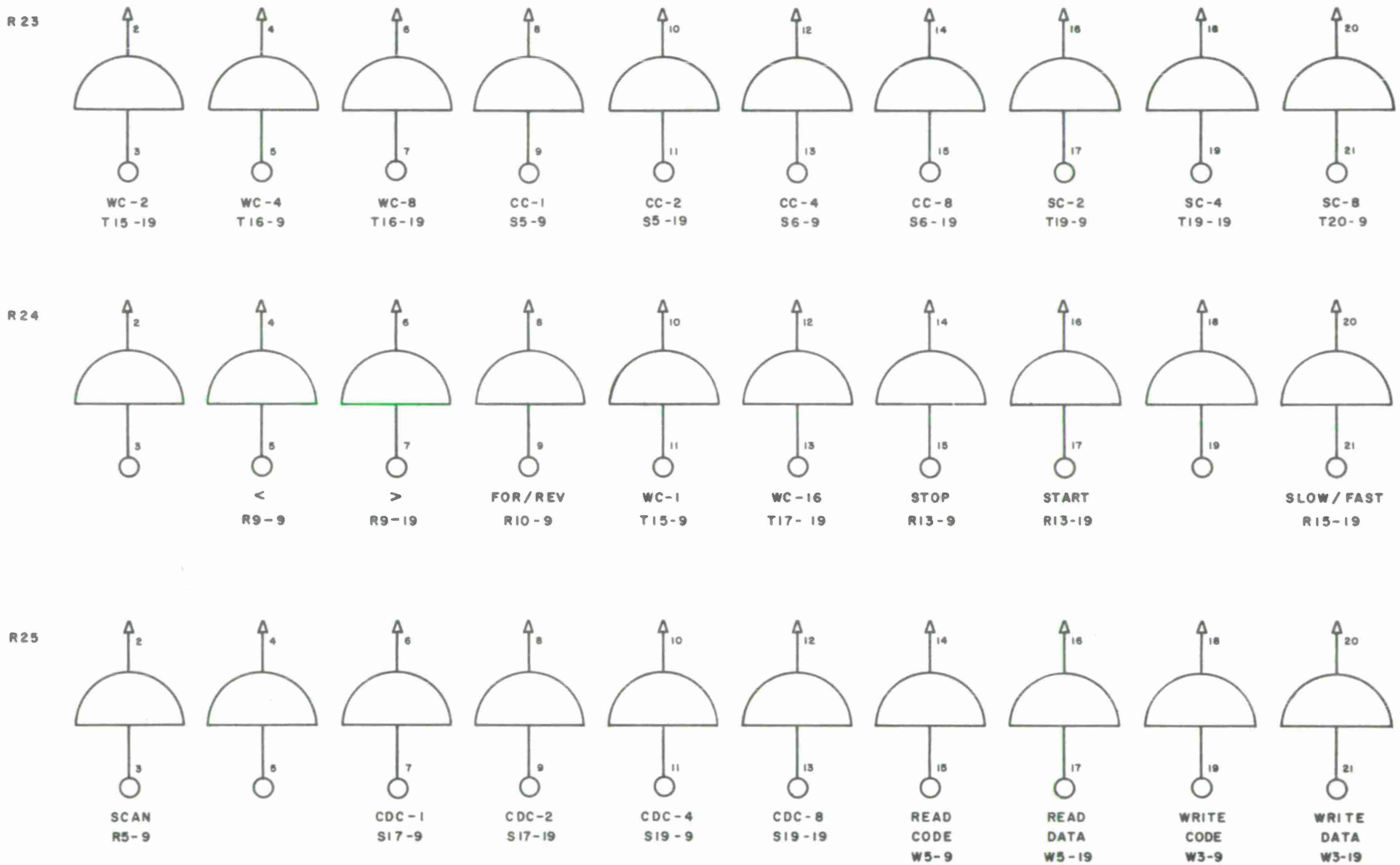


Figure 15. Indicator Amplifiers (Subrack B)

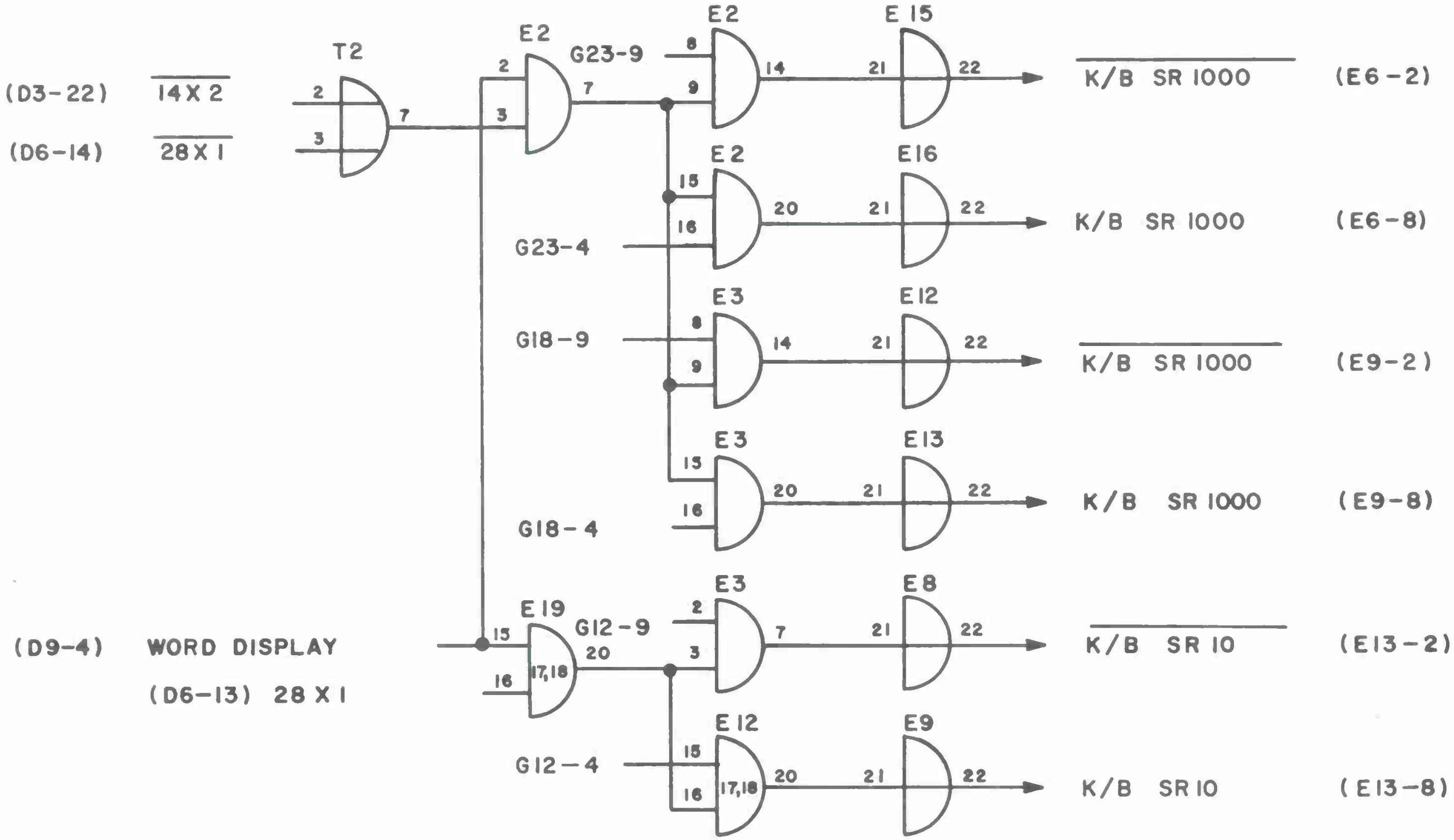


Figure 16. Display Decoders

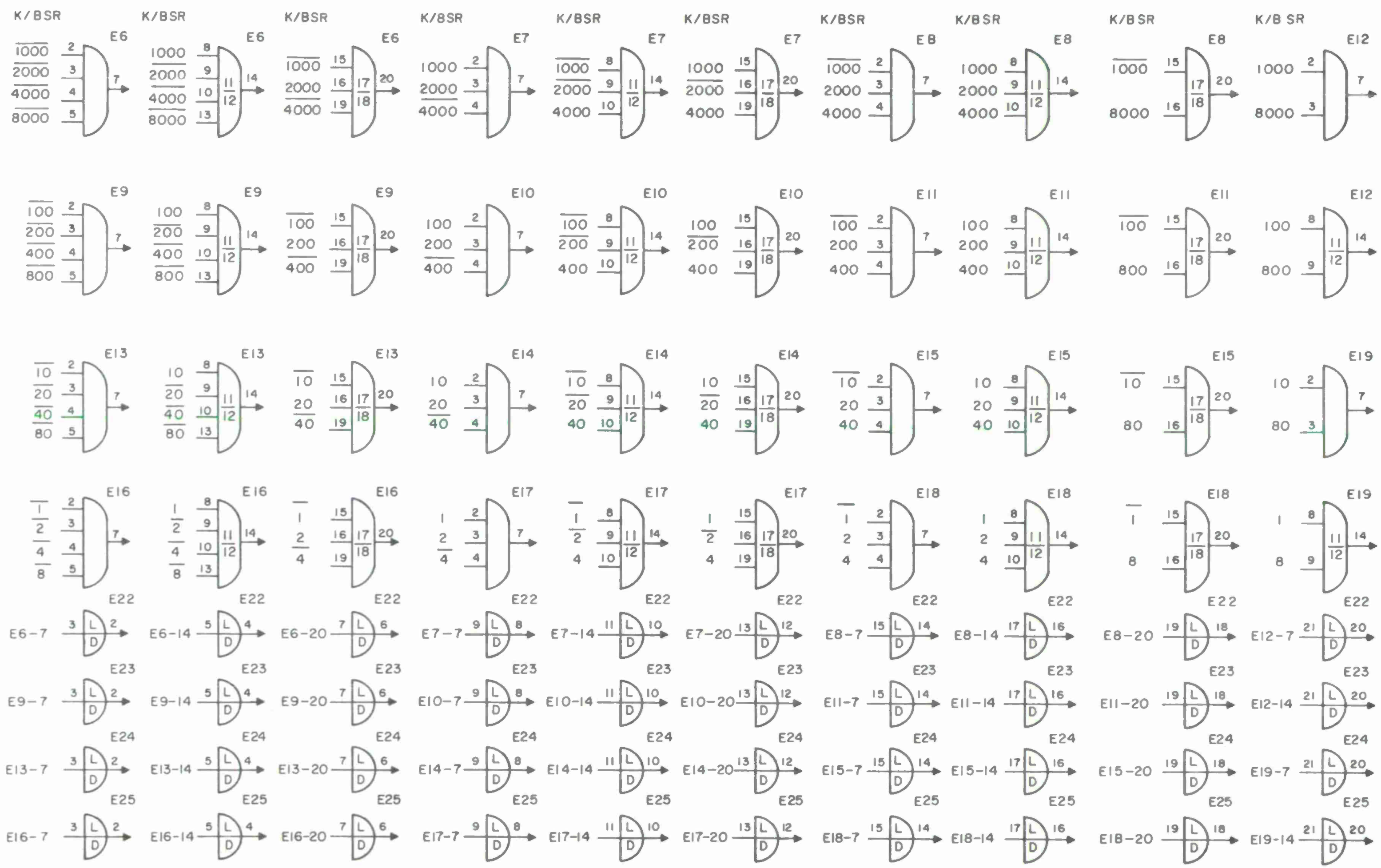


Figure 17. Display Drivers

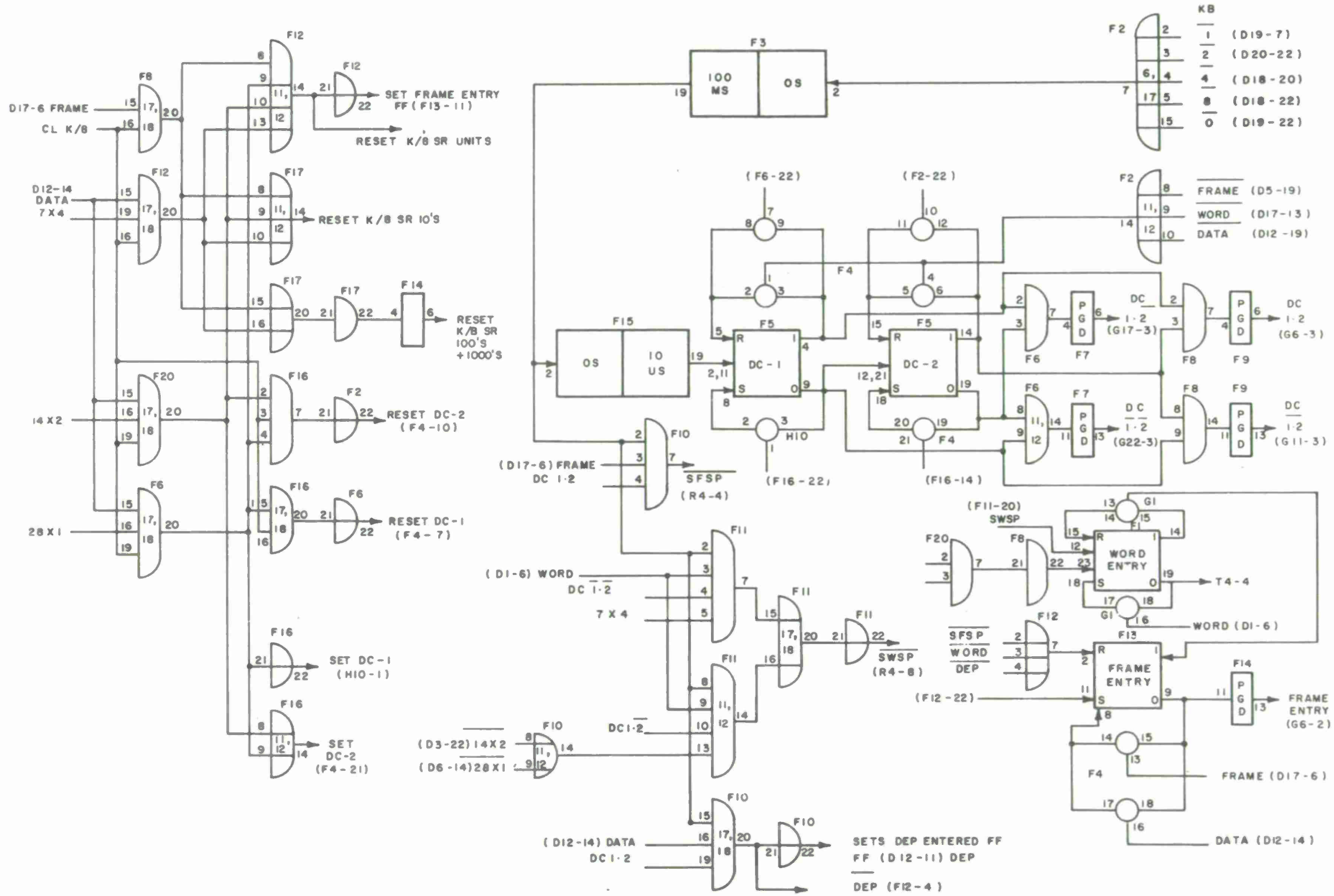


Figure 18. Keyboard Entry Control

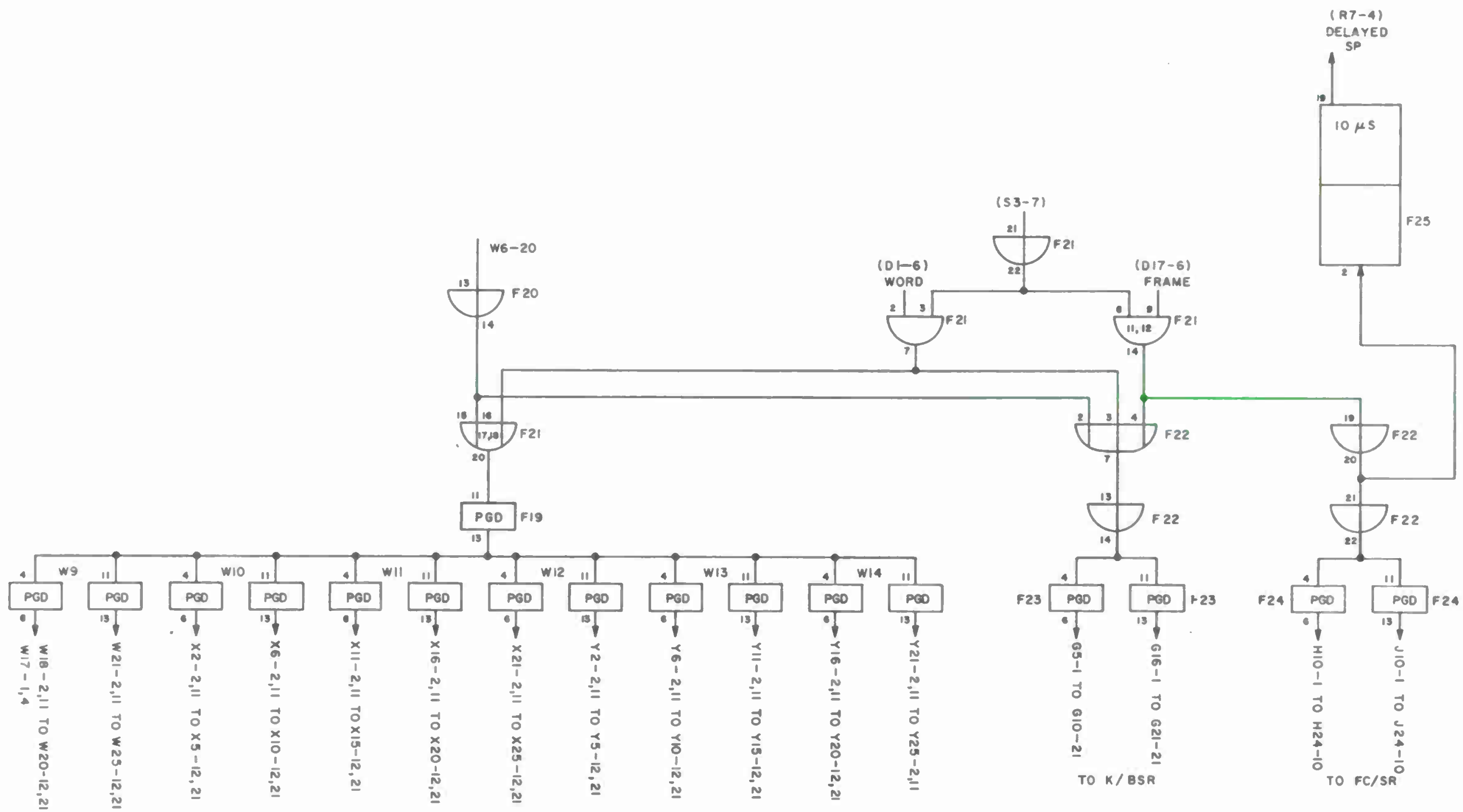
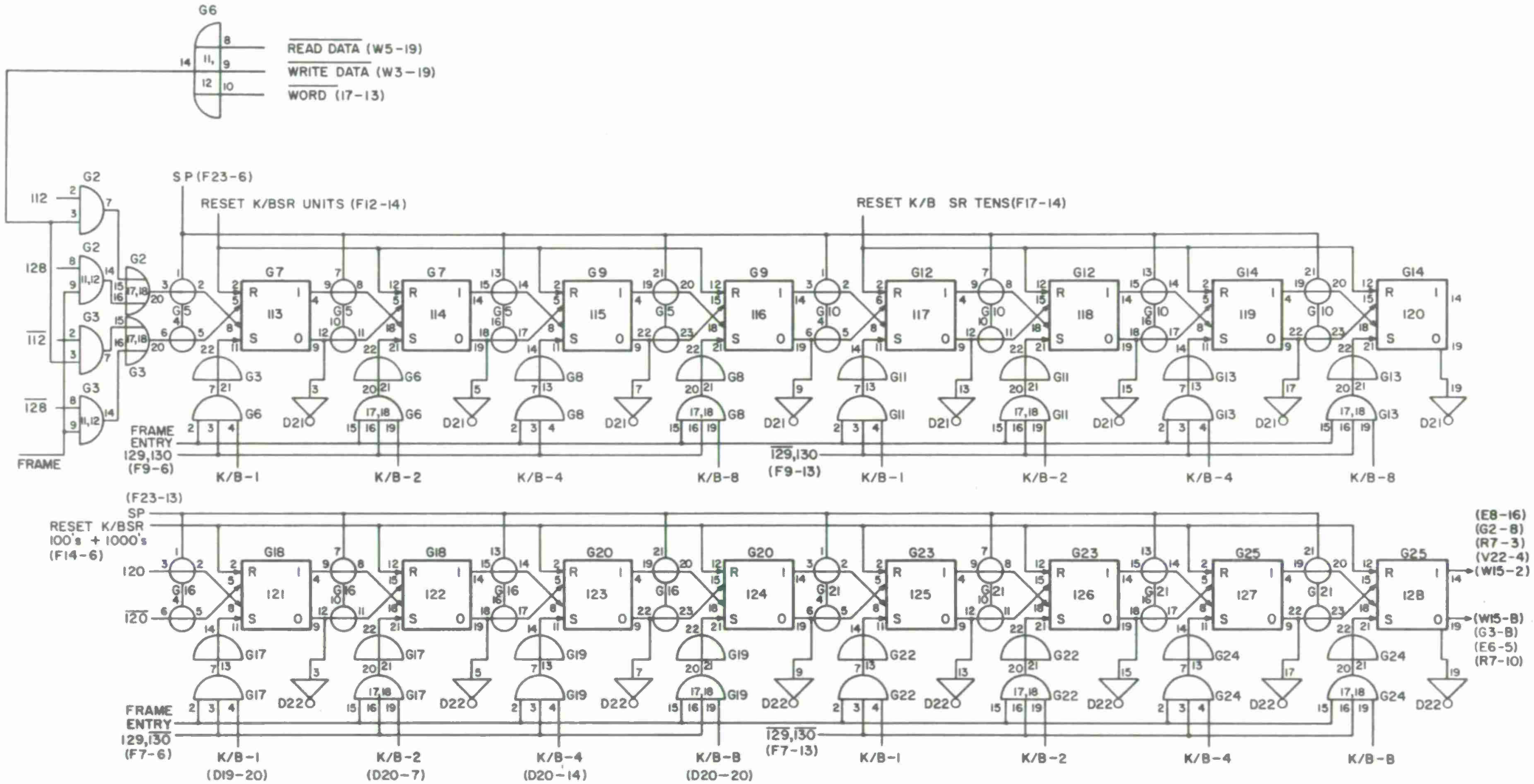


Figure 19. Shift Pulse Driver



CONNECT 3-5, 8-10, 13-15, 18-20 OF ALL FF's
GROUND 6, 7, 16, 17 OF ALL FF's

Figure 20. Keyboard Shift Register

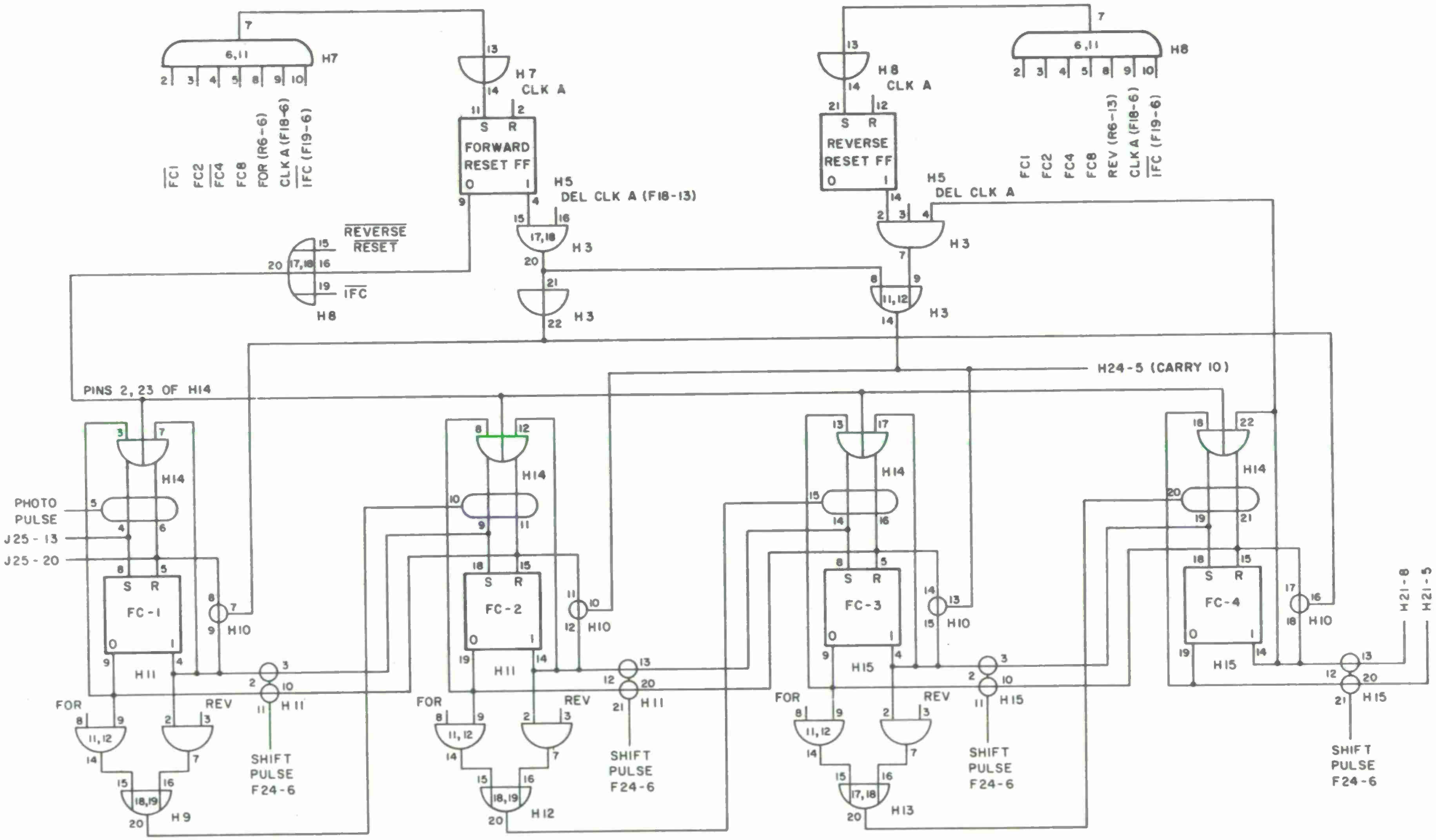


Figure 21. Registers 1-4 of 16 In Frame Counter/Shift Register

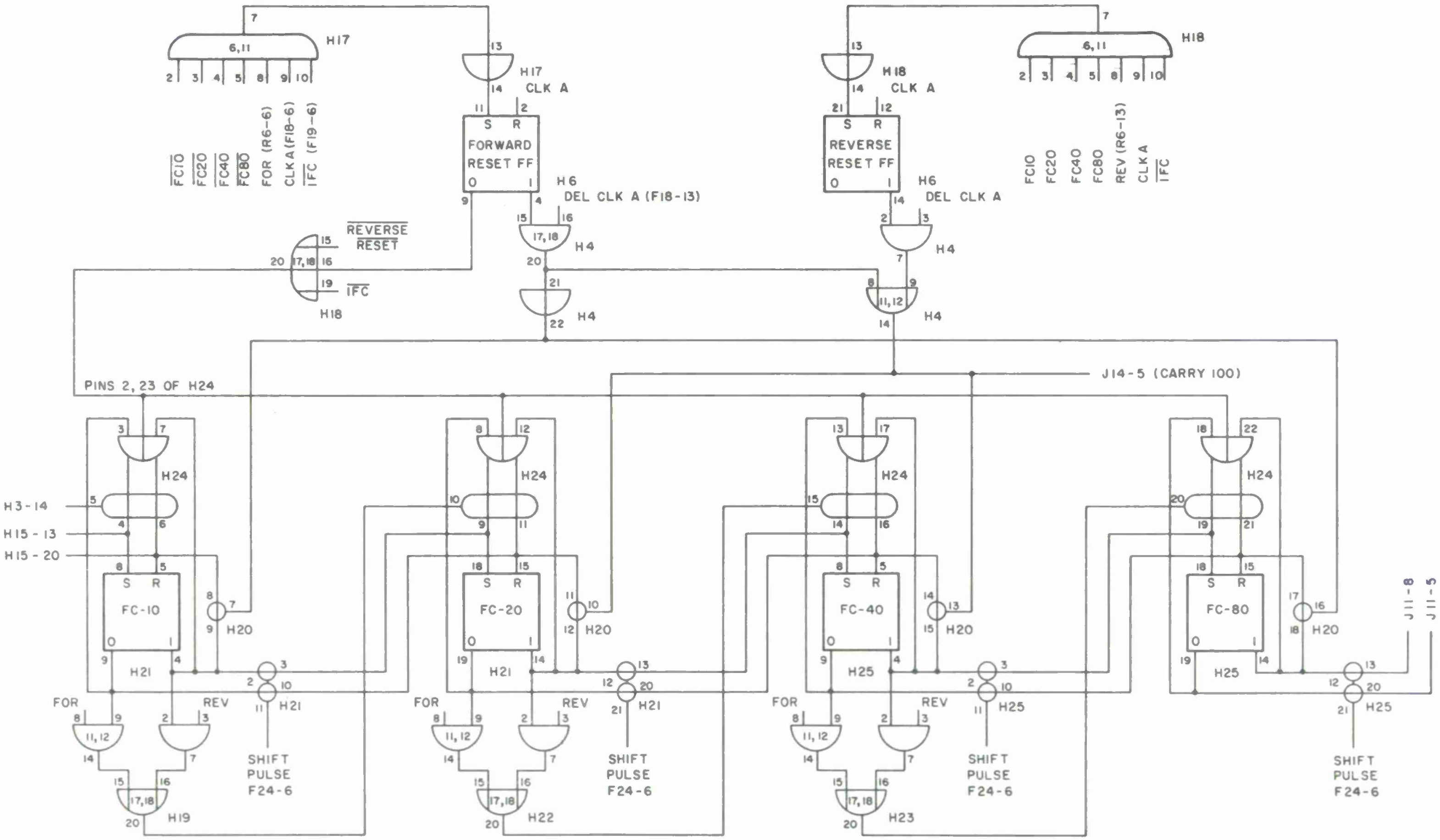


Figure 22. Registers 5-8 of 16 In Frame Counter/Shift Register

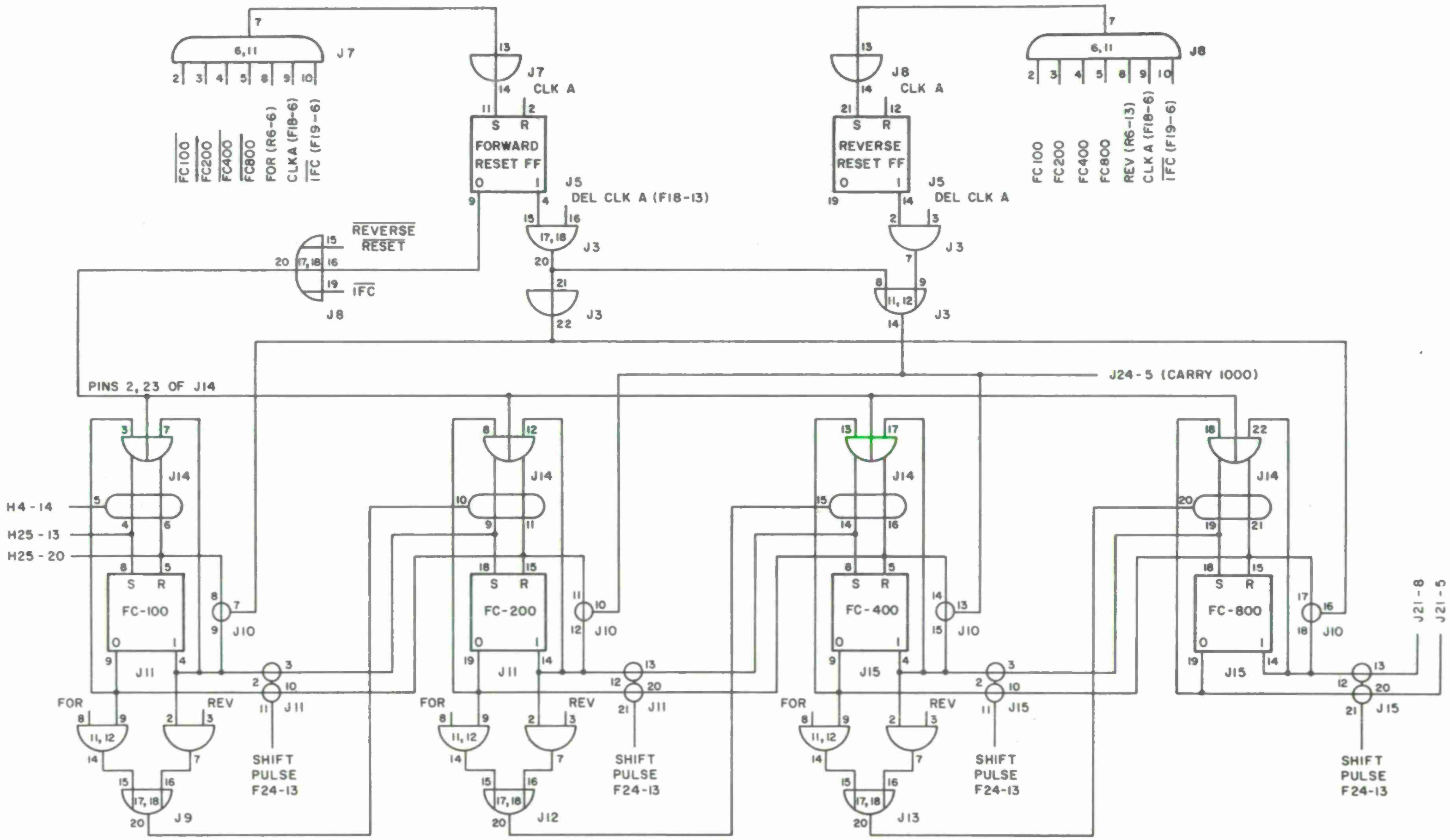


Figure 23. Registers 9–12 of 16 In Frame Counter/Shift Register

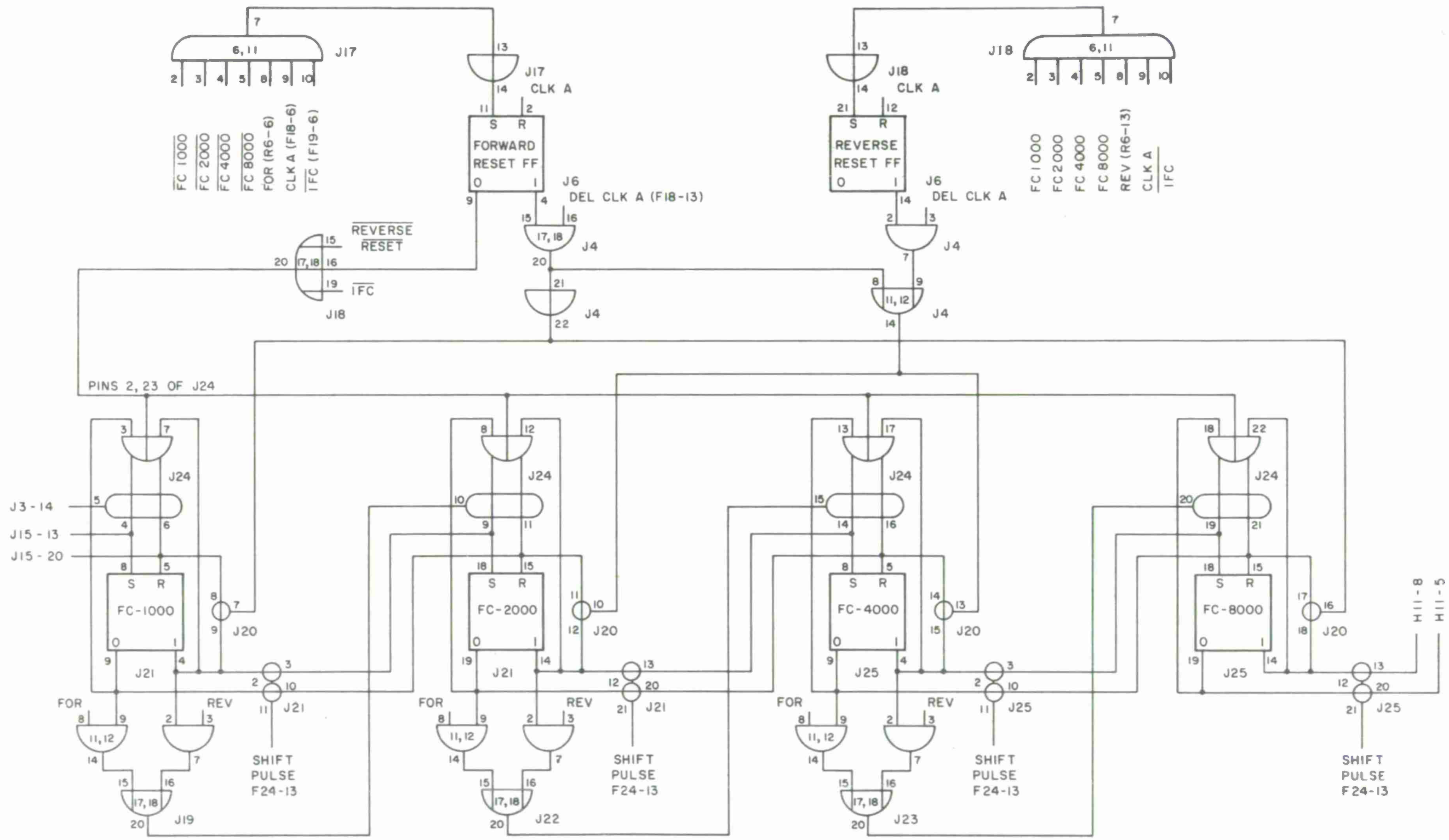


Figure 24. Registers 13–16 of 16 In Frame Counter/Shift Register

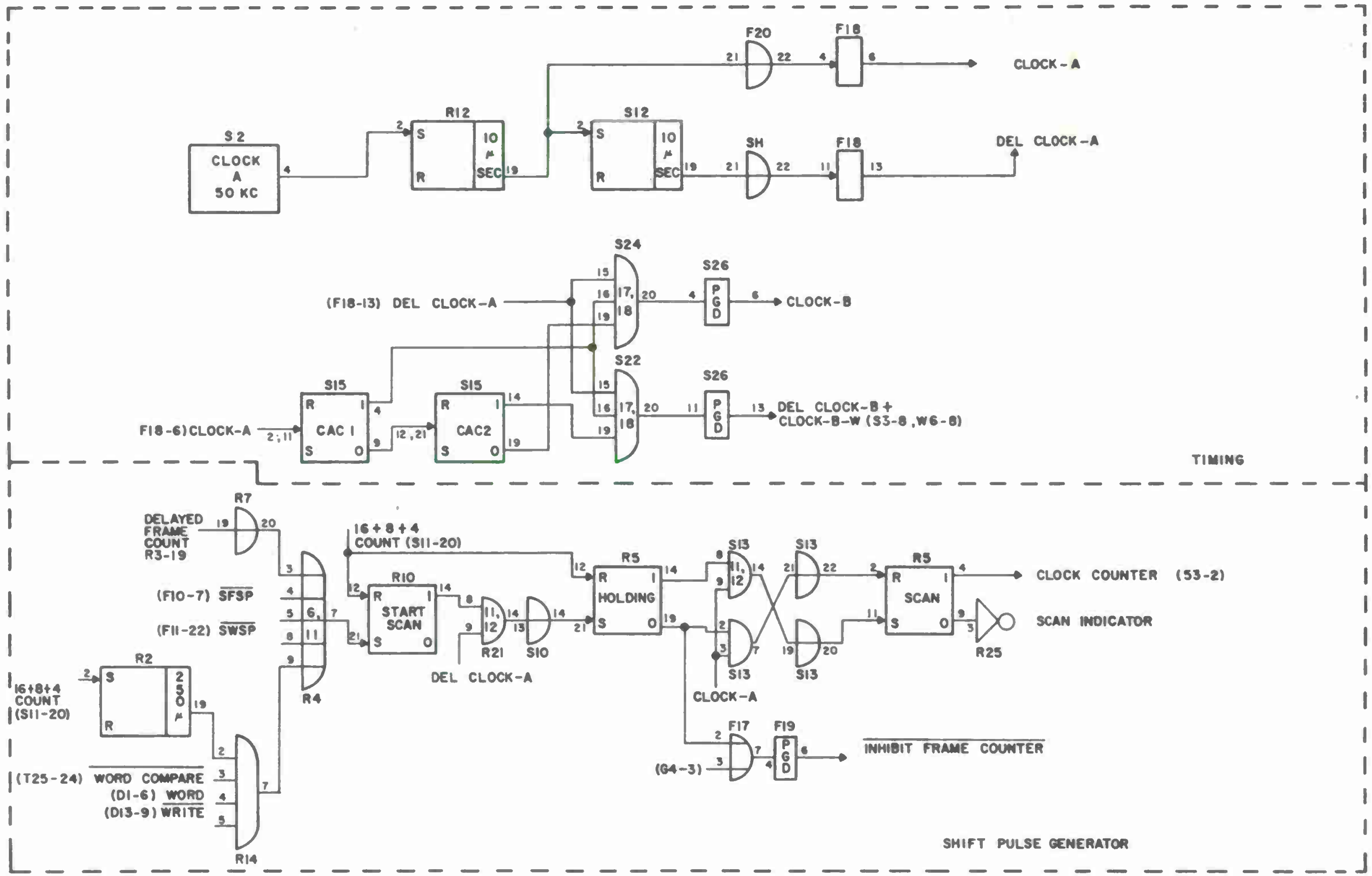


Figure 25. Timing and Shift Pulse Generators

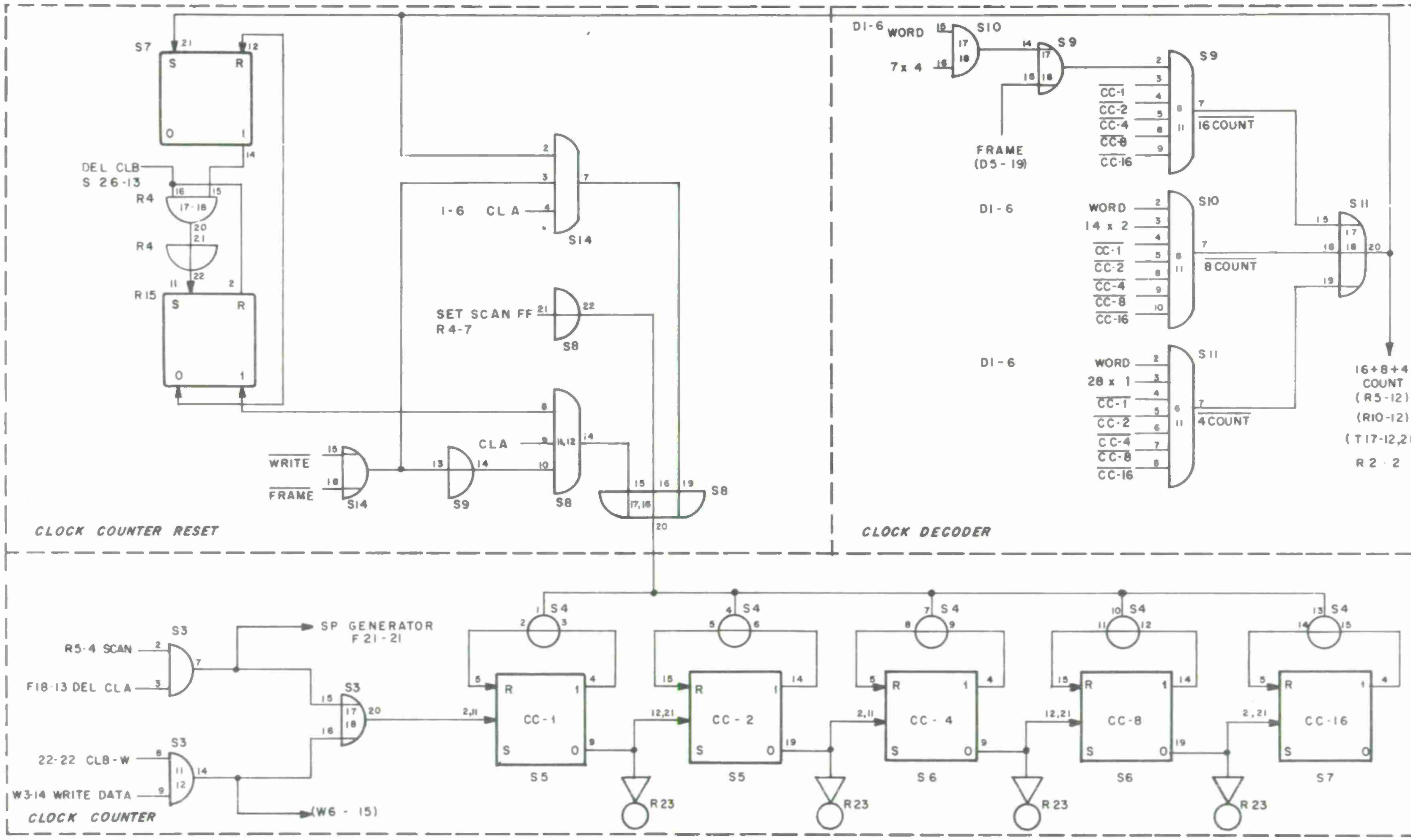


Figure 26. Clock Counter, Decoder, Reset Diagram

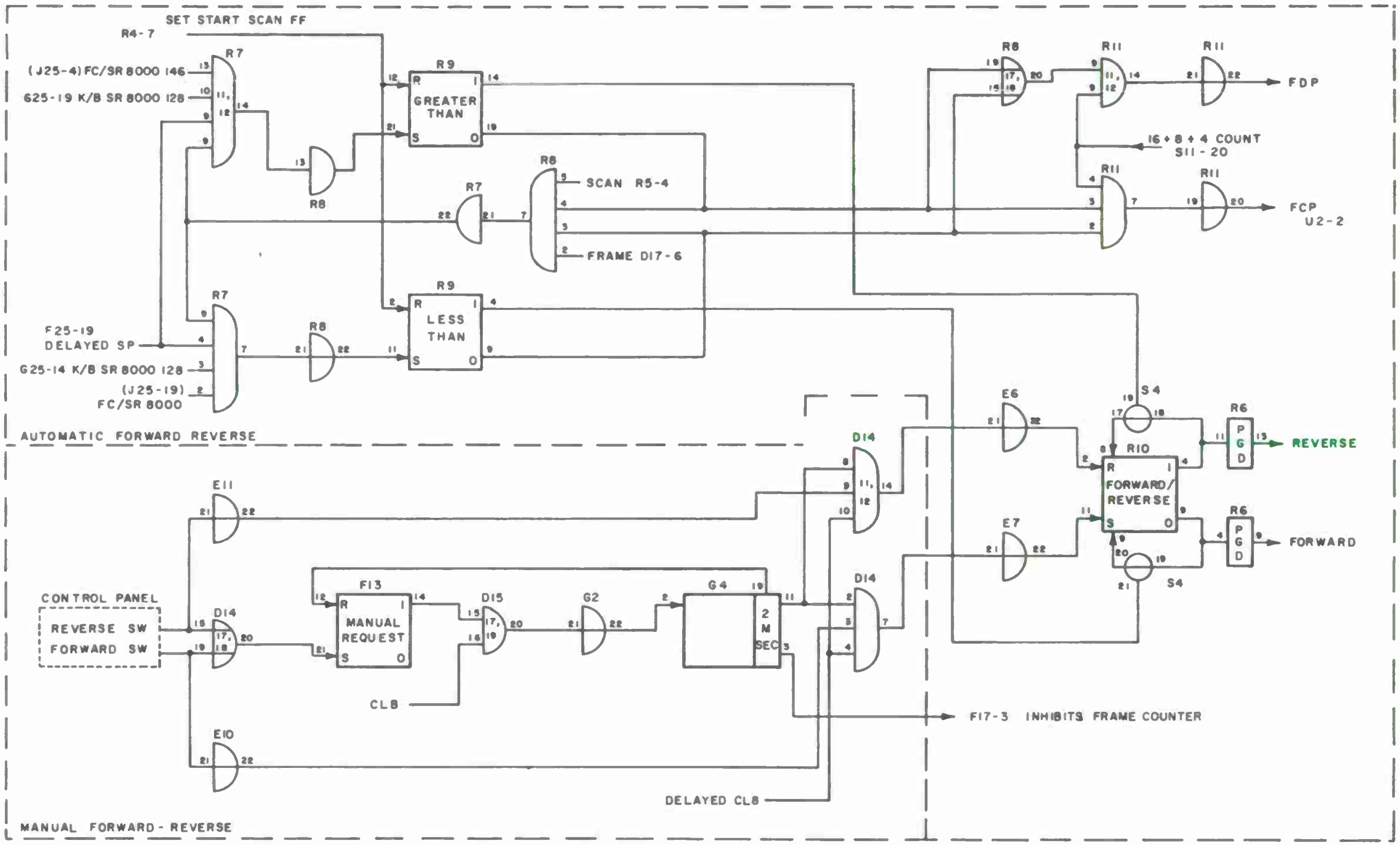


Figure 27. Forward/Reverse Control Diagram

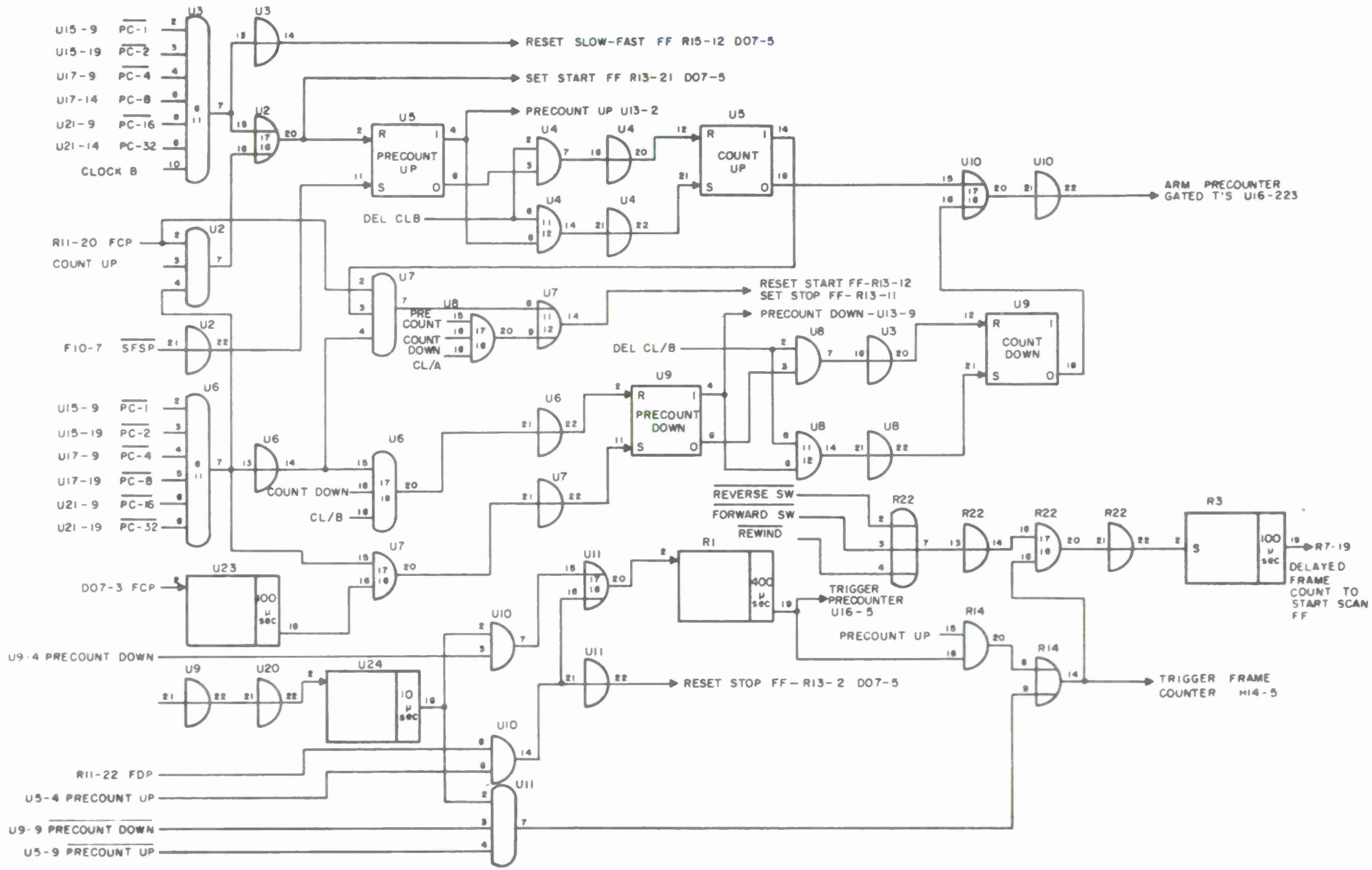


Figure 28. Precount Control

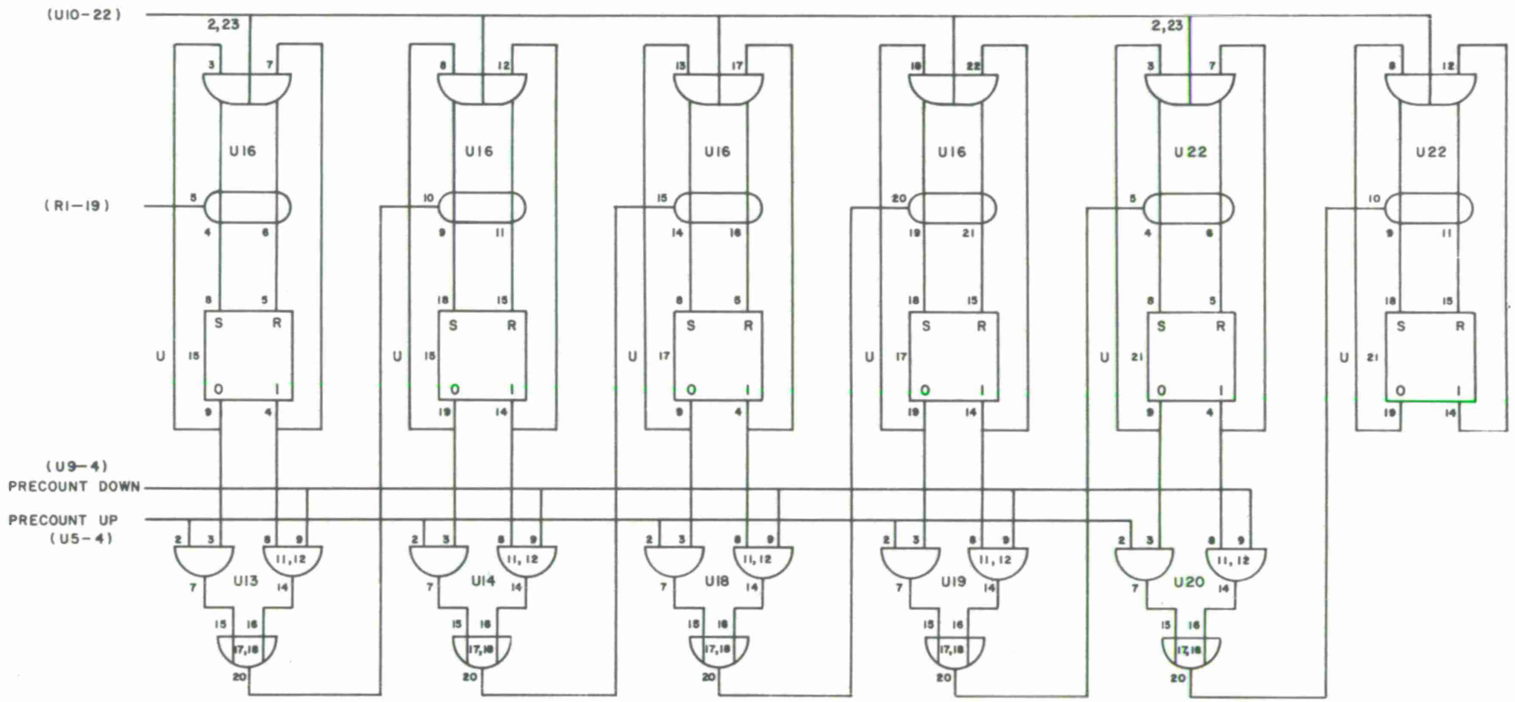


Figure 29. Precounter Diagram

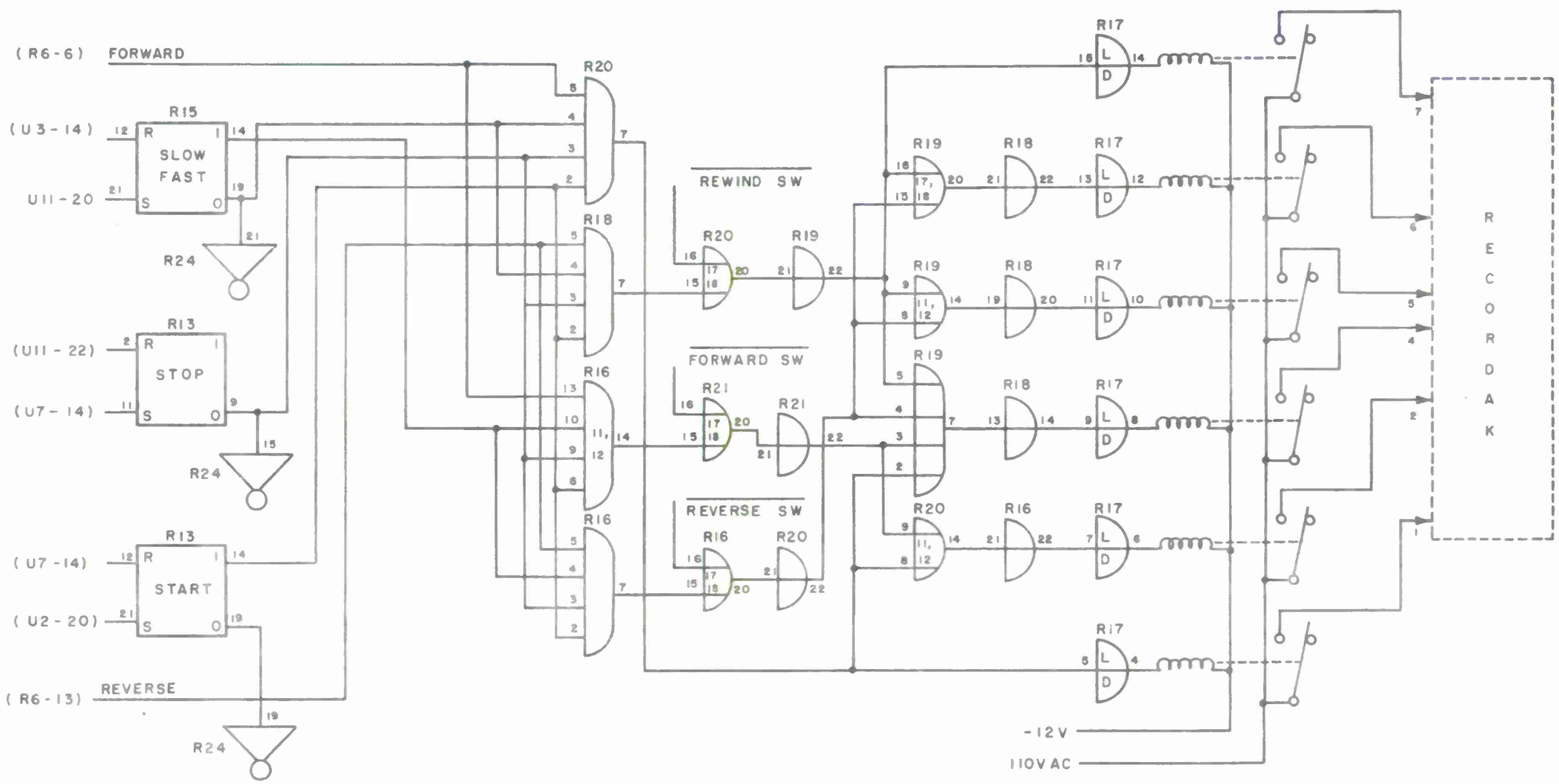


Figure 30. Selector Control for External Operation

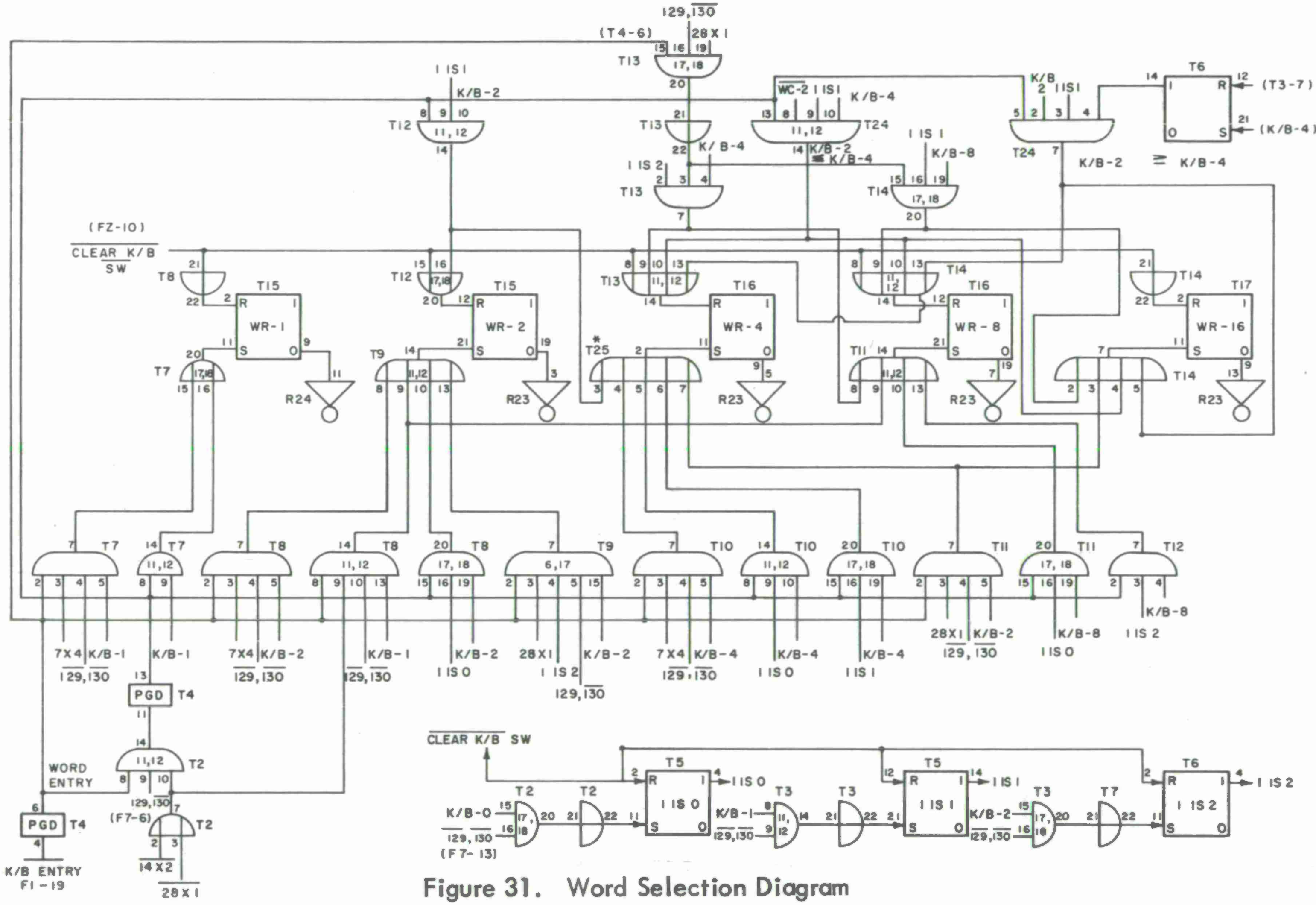


Figure 31. Word Selection Diagram

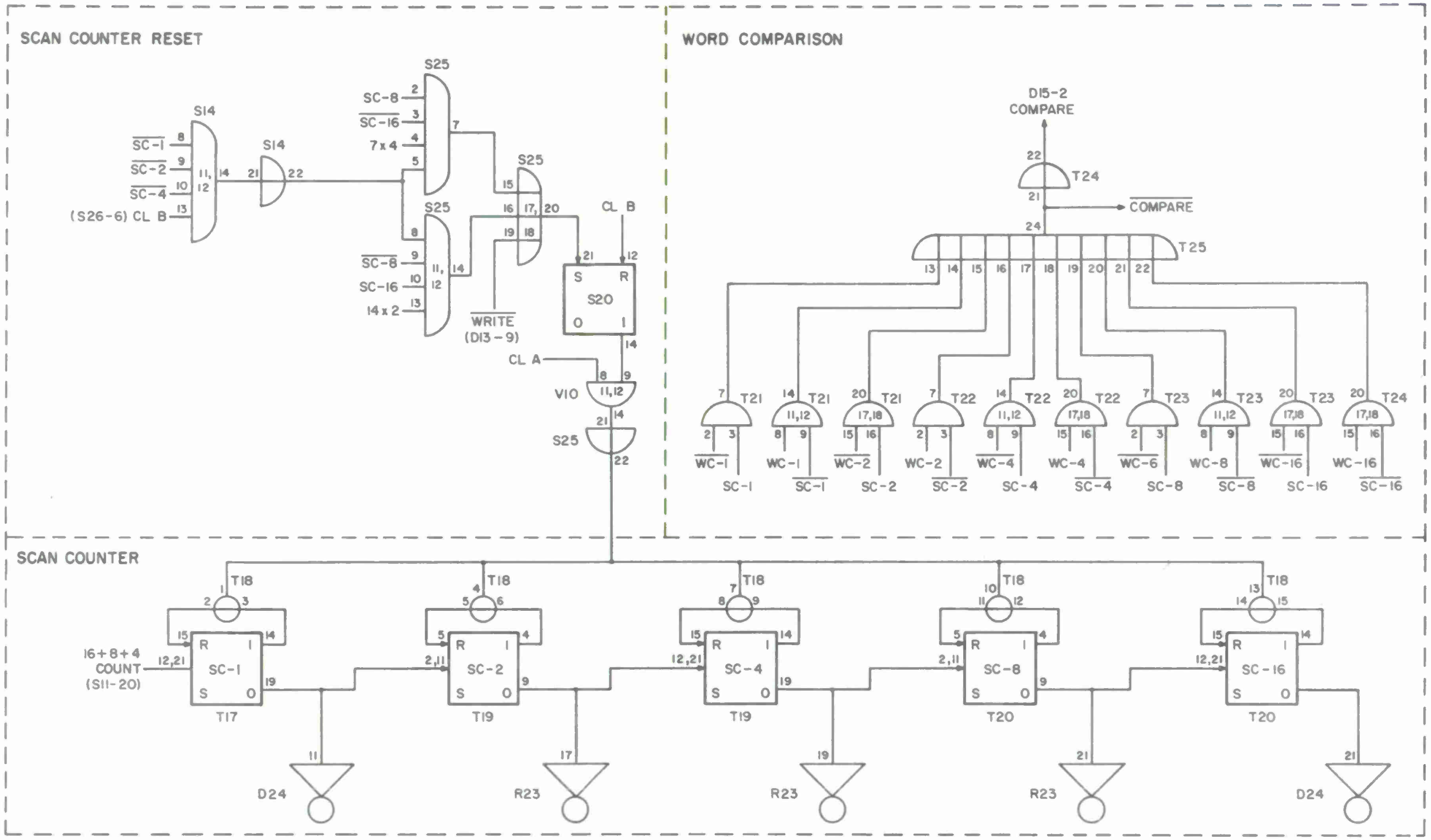


Figure 32. Scan Counter and Reset Diagram

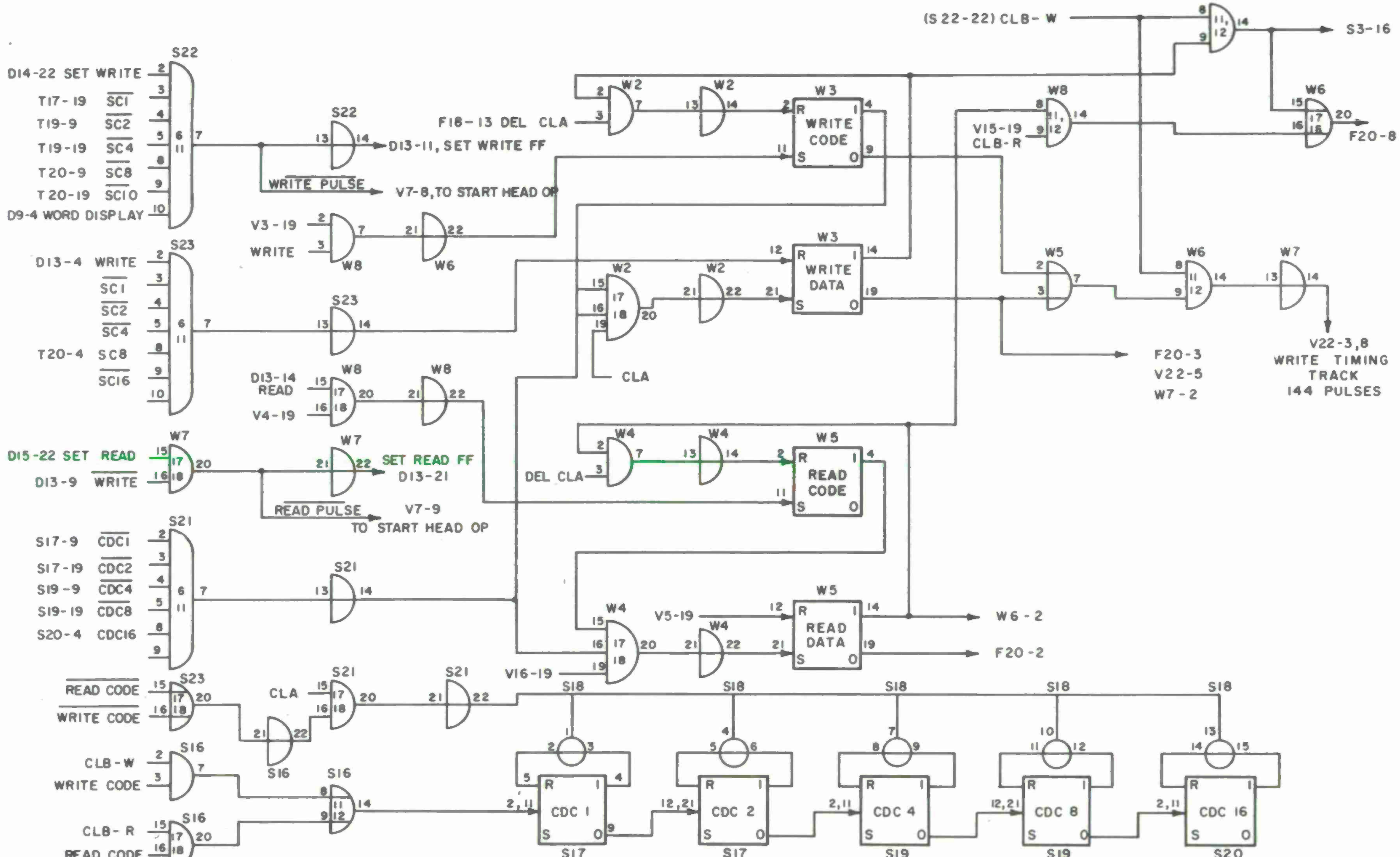


Figure 33. Read/Write Control

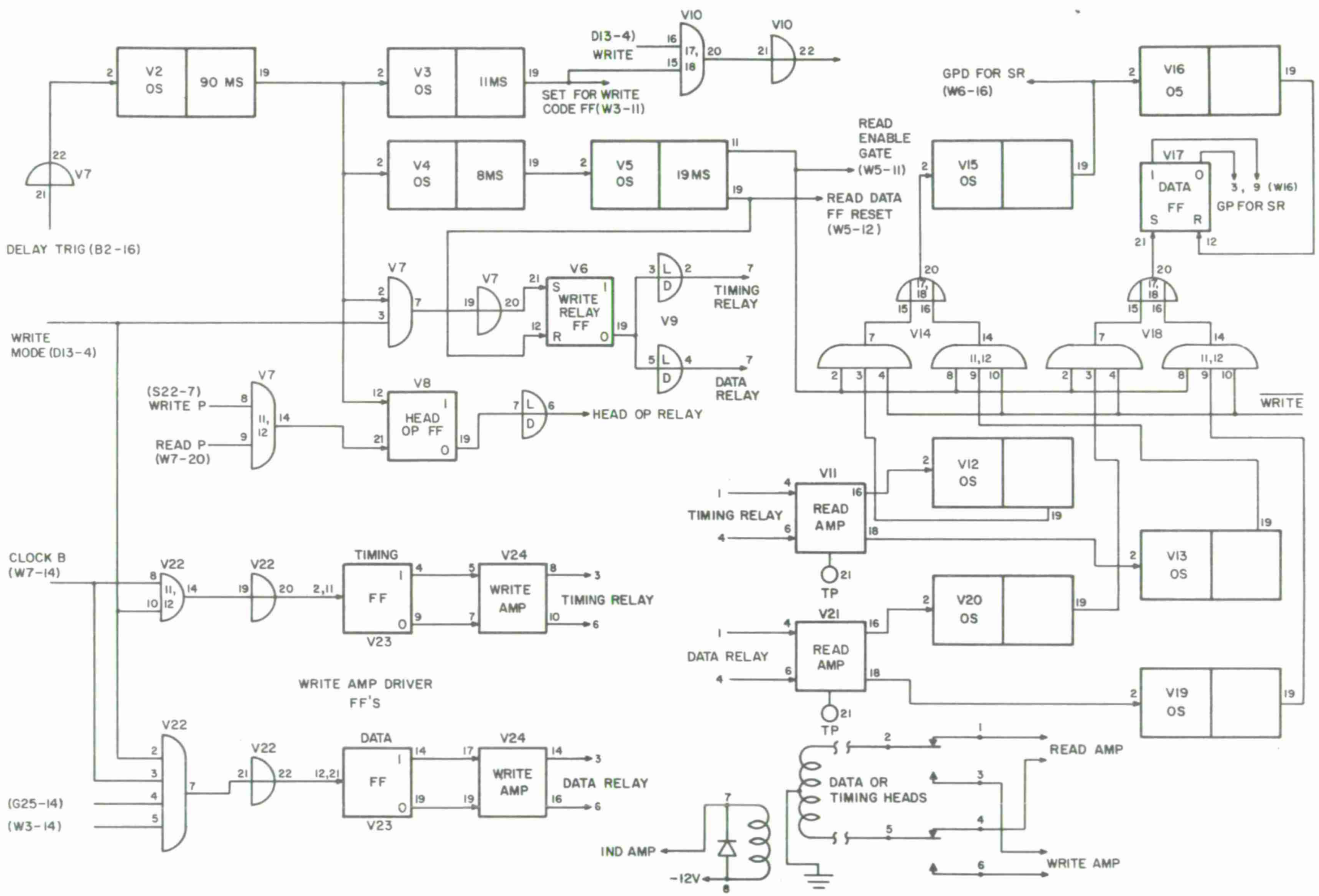


Figure 34. Read/Write Timing

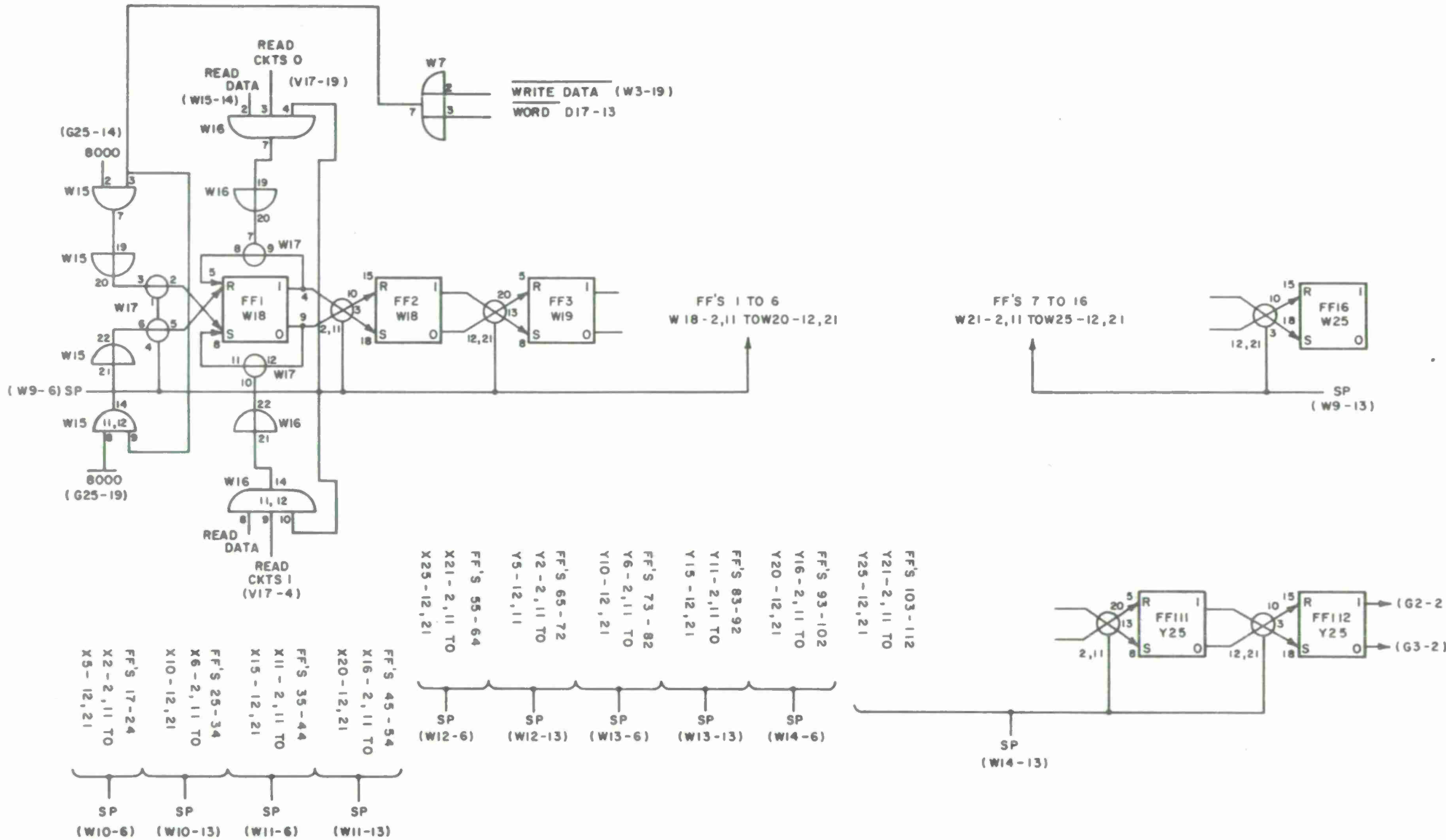


Figure 35. Data Shift Register (112 Bit BCD)

APPENDIX II

DESCRIPTION OF COMMERCIAL MICROFILM EQUIPMENT PROCURED FOR PROGRAM

A commercially available reader-printer was procured to serve as the basis in which to perform modifications. Studies revealed that the Recordak Model PESIC equipment possessed many of the desirable characteristics required in the prototype.

The Model PESIC reader-printer features magazine loading and is designed especially for frequent reference and high speed information retrieval. Visual display of a stored image is achieved by rear projection on a built-in screen. The optical path is designed to give a magnification of 23:1 on the reader screen.

Plastic magazines are used to contain the 100-foot reels of 16-mm unperforated microfilm. Insertion of the magazine in a slot in the side of the reader console turns on screen illumination. A keyboard module adds push button simplicity to retrieval of information on microfilm. An operator merely keys a given index into the control keyboard, presses the SEARCH button and the image of the desired document is flashed on the screen in a matter of seconds. The search technique is basically a counting scheme which utilizes a photocell sensing tube to count photo-opaque blips. Each blip (rectangularly shaped) corresponds to and is located under each document image. Output signals from the photocell are sent into a series of tube decade counters which provide capability for 4-digit counting.

If a facsimile print of the document is desired, the operator presses the print button, and the automatic exposure-print processing cycle is set in motion. A photo-accurate 8.5- by 11.5-inch paper print emerges from the front of the console unit within 30 seconds. Image search can be resumed, or additional prints started, 17 seconds after the first cycle has begun. The hard copy capability of the commercial reader has been maintained in the prototype.

Following is a set of descriptive characteristics for the Recordak Model PESIC equipment:

Magnification	...	Visual Display 23 X Hard Copy Print 21 X
Reader Screen	...	Translucent, tinted, daylight-type measuring 13 by 13 inches
Film Magazine	...	Self-threading, reusable, 4-inch square by 1-inch deep, capacity of 100 feet of 16-mm, unperforated film
Film Transport	...	Search: High speed - 600 fpm Low speed - 12 fpm Single frame advance and back space controls, rewind speed - 600 fpm
Main Unit Controls	...	Keyboard selector - four column, 40-key console (units, tens, hundreds and thousands) with 10 pushbutton positions in each column.
	...	Film selector - two-position slide switch to select for positive or negative film
	...	Control selector - six-button key column - "A" Advance Button. Film is advanced out of magazine from beginning of roll at high speed, with automatic stop cycle to pre-selected frame. - "+1" Single Frame Advance Button - "-1" Single Frame Return Button - "+" Slow Speed Advance Button - "–" Slow Speed Return Button - "R" Rewind Button. Film rewinds completely into magazine at high speed.

Electrical Requirements	...	115 v, 0. 6 amp, 60 cycle, a-c only
Size and Weight	...	Console - 31 inches high by 16 inches wide by 28. 5 inches deep; 143 pounds.
Console Controls	...	On-off switch, focusing lever, print button, exposure control knob
Hard Copy	...	Sensitized paper - supplied in 8. 5-inch wide rolls 250 feet in length. Rolls have a black paper leader to prevent fogging and to permit room-light loading - Printing Cycle - prints are automatically exposed, cut, processed and delivered squeegee dry at the front of the console unit above the reader screen hood. - Print Access Time - 30 seconds for the first print and 17 seconds for additional prints of same film image. Search can be conducted 17 seconds after the print button is pressed. - Processing Solution - Monobath-type can be used for approximately one week or 150 prints - whichever occurs first.

In order to provide high speed preparation of data base material on microfilm a commercial camera unit was procured. An automatic paper feed mechanism in the camera unit allows high speed microfilming of data base material. For purposes of compatability with the Recordak Model PESIC, a Recordak Reliant "500" was procured. The Reliant "500" is a rotary microfilm camera capable of filming rates up to 500 check-size (or IBM cards) or 185 letter-size documents per minute. Interchangeable film units are commercially available for 40:1, 32:1, or 24:1 reduction ratios. Accessory kits procured with the camera unit include 3-line Kodamatic indexing and the Automatic Image Designator kit. The former provides up to 1000 separate code line combinations while the latter automatically affixes a "blip" under each document image at the filming rates mentioned above.

Following is a set of descriptive characteristics for the Recordak Reliant "500" Microfilm:

Reduction Ratio	...	24:1
Film Encoding	...	3-line Kodamatic or blip
Controls	...	Positive interlock on-off switch - insures that document feeder and microfilm are turned off in proper sequence

- Frame Counter - high speed, resetable counter gives accurate count of number of items filmed.
- High speed feeder - accepts up to 500 check-size or 185 letter-size documents per minute also guards against "double feeding"
- Feeder adjustment control - for setting different thicknesses of documents being photographed
- Spacing lever - adjusts spacing between document images
- Method lever - selects which surface of documents are to be filmed; upper, lower or both
- Film unit - magnetically locked in place allows fast removal and interchangeability
- Shutter motion signal light - displays proper operation of the camera shutter
- Film indicator - shows remaining film length in feet.

- Film motion indicator - displays proper film motion.
- Camera module lock - prevents unauthorized removal of film unit and guards against accidental fogging of film.
- Receiving chamber - adjusts instantly for varying document sizes
- Indicator lights - a pair of indicators show the method of microfilming whether upper, lower or both surfaces of document

Size	...	Camera unit: 17 inches high by 24 inches wide by 31 inches deep (with feeder)
		Work station: 23-1/4 inches high, by 23-1/2 inches wide by 25 inches deep (width with shelves extended is 57 inches
		Image mark designator: 9-1/2 inches high by 12 inches wide by 6 inches deep
Weight	...	Approximately 80 pounds total

APPENDIX III

DESCRIPTION AND UTILIZATION OF THE RECOVERY DATA BASE PREPARED ON MICROFILM

GENERAL

A typical data base was prepared and filmed in order to provide a meaningful demonstration of the microfilm prototype capability. The content of the data base closely simulates the information required to support a version of a recovery function (i. e., criteria for the recovery of returning strategic aircraft). Although the information content possibly resembles that of a realistic SAC operation, the data base is strictly fictitious and thus not classified.

DATA BASE DESIGN

A realistic data base cannot be designed without establishing well-defined functional requirements. It is difficult, and perhaps impossible, to know what data must be in the base without defining the nature of the output. One must know the class of questions to be answered before a decision can be made as to the amount and kind of information necessary in the file content. For these reasons, certain hypotheses were established and the results that follow were based on these hypotheses.

DESIGN HYPOTHESIS

By recovery is meant the assignment of returning aircraft to bases located within the remaining range of the aircraft. Functionally, the returning aircraft would enter CONUS by either of three established safe passage corridors. Each aircraft would report to a Ground Control Point (GCP) in the appropriate corridor as to his present position (lat-long.), range remaining (nautical miles), and maintenance and fuel requirements. This aircraft would then be assigned to one of a number of recovery bases within his remaining range. The criteria to be used as the basis for the assignment of the aircraft to a particular base is:

(1) Base capability as a function of reassignment of the aircraft for follow-on missions, and

(2) Dispersion, especially of the same aircraft type, to prevent bonus destruction of the aircraft due to enemy weapons expenditures on the recovery bases.

CLASSIFICATION OF DATA BASE INFORMATION

For the purpose of this data base the information to be stored was classified into two general classes:

(1) Static information, and

(2) Dynamic information.

Static information is defined as that data which will not change during the mission time of the system.

Dynamic information is defined as that data which will change one or more times during the mission time of the system.

For this data base a logical division of the file content results in the storage of the static information photographically and magnetic storage of the dynamic information. As previously mentioned, these two storage techniques utilize the same physical storage medium.

DATA BASE GENERAL CONTENT AND METHOD OF ENTRY

For the purpose of information retrieval associated with the performance of the recovery task, it is assumed that three GCP's have been established with communication capability from them to the returning aircraft. It has been hypothesized that these aircraft will return from their initial strike from the

North of CONUS through the safe passage corridors established by these GCP's (see Figures 36, 37, 38). The communication area of coverage at each GCP has been divided into 16 sectors of equal geometrical areas. For purposes of simplicity, a reporting aircraft in any sector of a GCP is assumed to be located at the geometrical center of gravity of that respective sector. The distances from the centers of each sector to all designated recovery bases have been calculated by computer and the print-out microfilmed and tabulated. Distances have been listed in 100-nautical mile increments from each sector center. Fudge factors were included in the calculations to account for aircraft positions in any extremity of any sector. This means that if a particular tabulation shows that an aircraft can reach a recovery base within its remaining range then it is indeed true that it can.

Another means of data base entry is alphabetically by base name. This tabulation was established in order to achieve and maintain current base status of all bases involved in the recovery function. Hence, there are two direct means of data base entry.

(1) By sector areas arranged and indexed by numerical order, or

(2) By base name arranged and indexed by alphabetical order.

DETAILED DESCRIPTION OF DATA BASE CONTENT

The following contains the numbers and types of data files included in the data base allocation. A data file can consist of one or more reduced images of 8-1/2- by 11-inch page size. Each file has been assigned a frame number which represents the reduced film image of the above pages.

FRAME ALLOCATION

1.	Distance Frames (16 sectors/GCP x 3 GCPs)	1177 Frames
2.	Individual Base Capability Files	241 Frames
3.	Base Capabilities Summary	1 Frame
4.	Individual Base Weapon Capability	241 Frames
	TOTAL	1660 Frames

As mentioned above, some of the data files could be multiple pages so that the entire data base is contained in 1757 pages.

Figures 39, 40, 41 and 42 show examples of each of the four above frame categories.

A HYPOTHETICAL EXAMPLE

Let us assume that the data base described above has been formatted and filmed. The 1757 pages of this data base are now contained in a magazine measuring 4 by 4 by 1 inch. This magazine is now loaded into the prototype reader/retriever. We will now show how the prototype capability can be utilized to retrieve the desired information, display the retrieved image and update the data base according to current status reports.

A hard copy index, tabulated and inserted into a loose leaf binder, serves as the sole data base index. This index allows file entry either by base name alphabetically or by sector number. Two different cases will be considered to illustrate both indexing techniques.

For the first case, assume that a returning aircraft reports into GCP 1 and his report includes the following:

Present Position - 48°N, 63°E

Range Remaining - 1466 nautical miles

Aircraft Type - B-52

Maintenance Required

New Crew Required if Aircraft Reassigned for New Mission

Weaponry Required if Aircraft Reassigned for New Mission

Since the data base index includes the map shown in Figure 36, a quick reference to it shows that this aircraft is now in Sector 1. We would now enter the loose leaf index by flipping the tab labeled Sector 1. This page of the index lists the frame location of all those bases between 1401 and 1500 miles from the center of Sector 1 and shows that these bases are tabulated on frame 106. The operator inserts the frame 1-0-6 into the input keyboard and the reader/retriever automatically locates and displays the contents of this frame on the built-in screen. This display will be in the form shown in Figure 38. Assume that Kansas City has been tentatively selected as a recovery base for this aircraft. It has been selected because it is within the aircraft's remaining range and this base originally had facilities for B-52 maintenance. It is now quite logical to inquire about the more detailed information relating to this base (i. e. , present status, facilities, weapons available, etc.).

Figure 39 shows that the Individual Base Capability information for this base is stored on Frame 121. The operator enters 1-2-1 into the control keyboard and the reader/retriever automatically locates and displays the contents of Frame 121 on the screen (see Figure 40). The 32 numerical characters associated with Frame 121 are now read from the magnetic strip on the film into the keyboard shift register. The operator may now select any of the numbered items in the column at the left of Figure 40. One simply depresses the WORD button on the control panel, and then enters the word number desired into the control keyboard. If the operator wanted the base status of Kansas City then he would depress button 1 on the keyboard and the four-character assignment for word 1 would be displayed on the accessory display. As shown in

Figure 40 there is a direct correspondence between the item numbers in the column at the left and the four character word assignment (i. e., numerical characters within dashed boxes).

Assume that the operator selects Kansas City as a recovery base for this aircraft on the basis of the information shown. He would then enter the appropriate update changes via the control keyboard in order to maintain up-to-date information on this base. For example, he may, by having assigned this aircraft to this base, have used up: a B-52 Turnaround Capability (item 2), a B-52 crew (item 4), some fuel (item 6), and added one aircraft to item 8. Additional updating (see Figure 63) may be required on the Summary Files. These files are cross-referenced and indicate that additional updating, may be required on Frame 1419 (Base Capability Summary) and Frame 1525 (Individual Base Weapon Capability). Figures 41 and 42 show the information contained in Frame 1419 and Frame 1525, respectively. If update changes are required on either of these frames the operator simply keys these numbers into the keyboard and the reader/retriever automatically locates and displays the desired information in a matter of seconds as described previously. We shall now consider that this particular recovery task is complete and describe the other technique for data base entry as the result of reception of a base destruction report.

Let us now assume that a report has been received that the base Loring has been completely destroyed and follow the sequence of events necessary to update our data base. As mentioned previously, the data base was indexed alphabetically. The operator then selects the "L" tab in the loose leaf index and finds that the Individual Base Capability frame for Loring is number 4. The number 4 is entered into the control keyboard and the reader/retriever locates and displays frame 4 (see Figure 43). The magnetic head traverses the film strip and reads the information for this frame into the shift register. Now the operator inserts the update information appropriate to the base destruction report (e. g., Base Status, item 1, is now closed). The destruction of the other items (i. e., 2 through 8) is subtracted from the totals in Frame 1419 (Base Capabilities Summary) and the new totals re-entered via the keyboard and written back onto the magnetic strip via the read/write head. Future references to these files will yield complete up-to-date information. Figure 44 shows the Individual Base Weapon Capability for Loring. If there were weapons at Loring prior to this destruction report the loss of these weapons would be entered on Frame 1661 (Weapon Summary Frame) in the same manner as described previously.

IB-14, 171

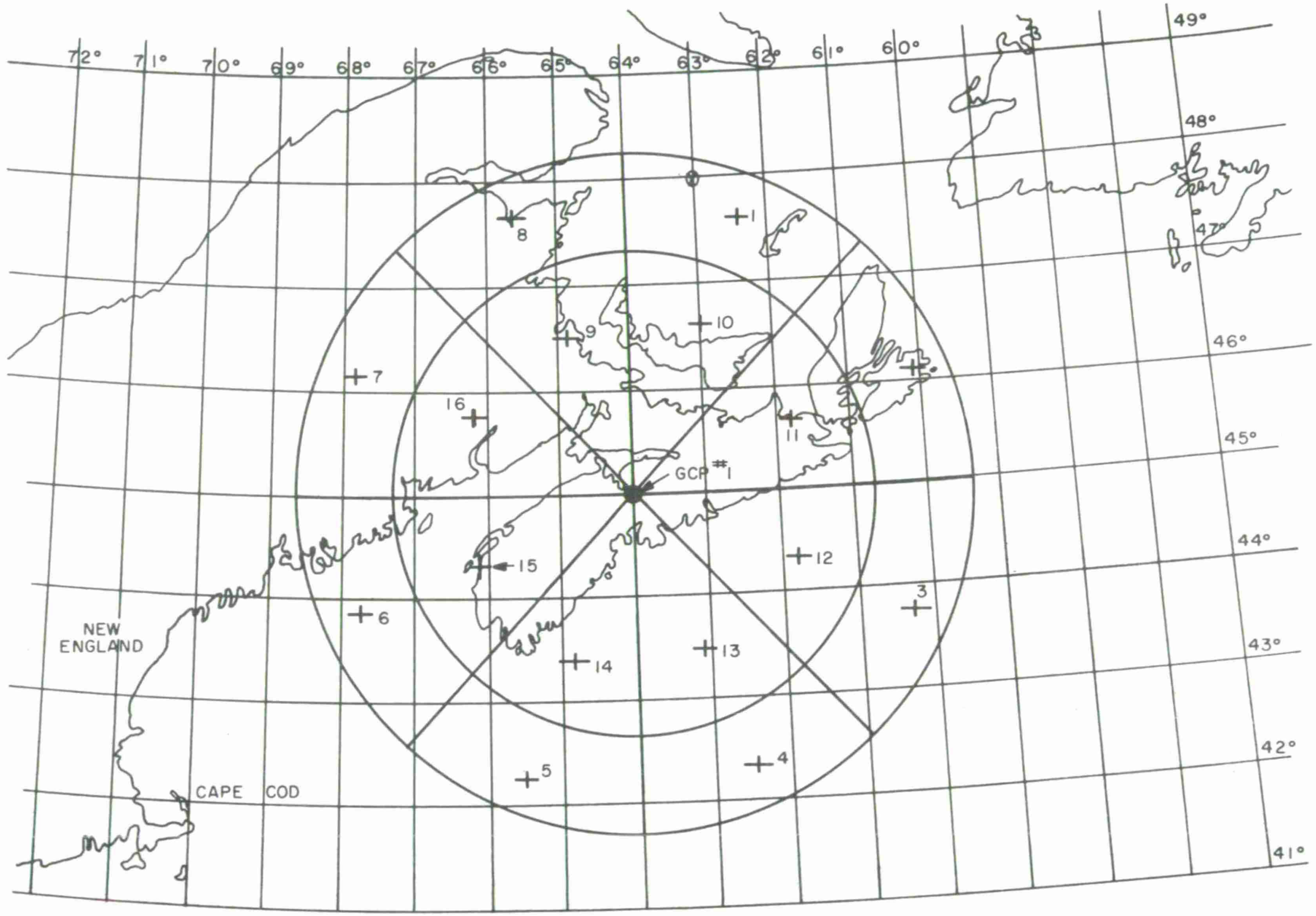


Figure 36. Ground Control Point No. 1

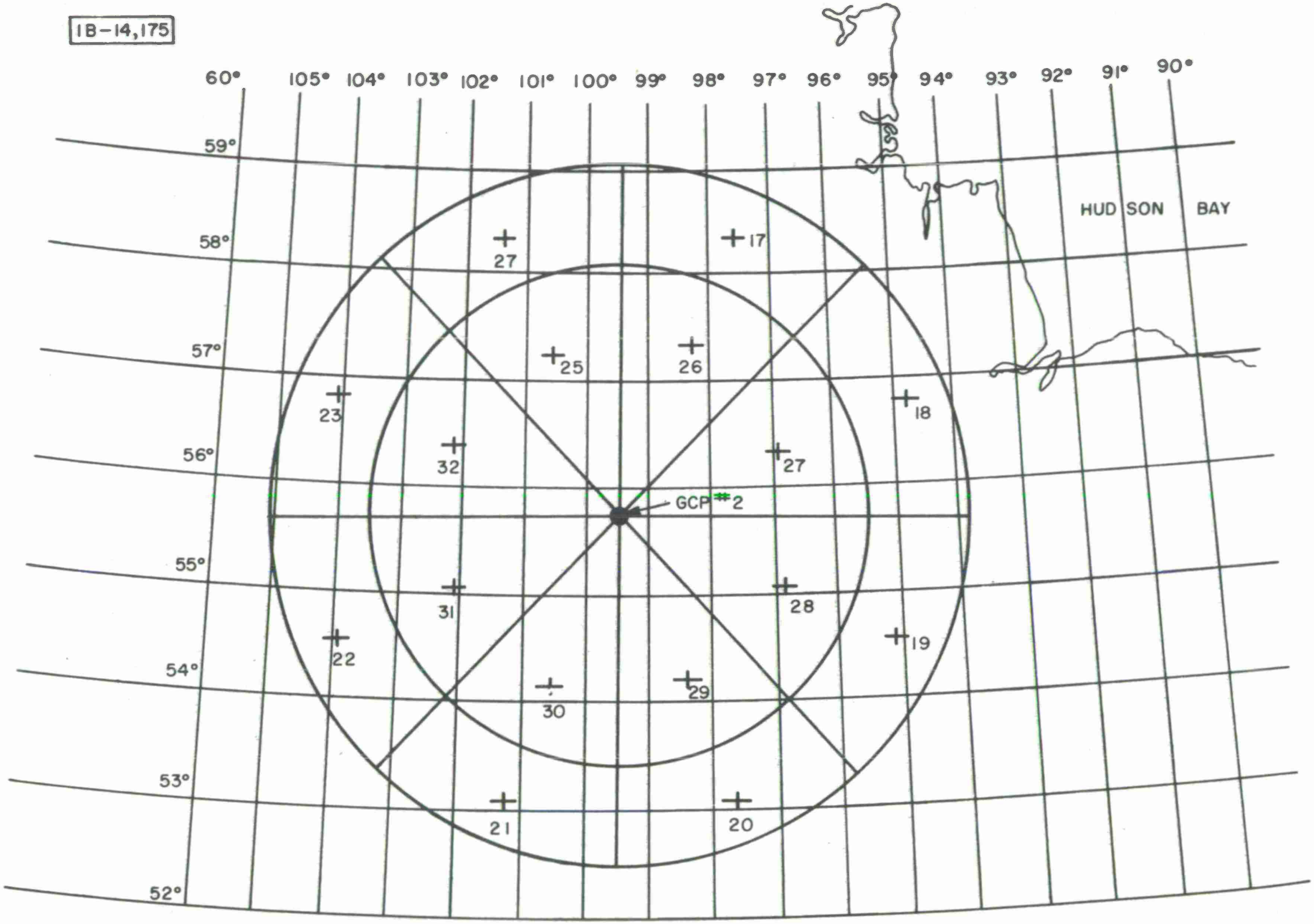


Figure 37. Ground Control Point No. 2

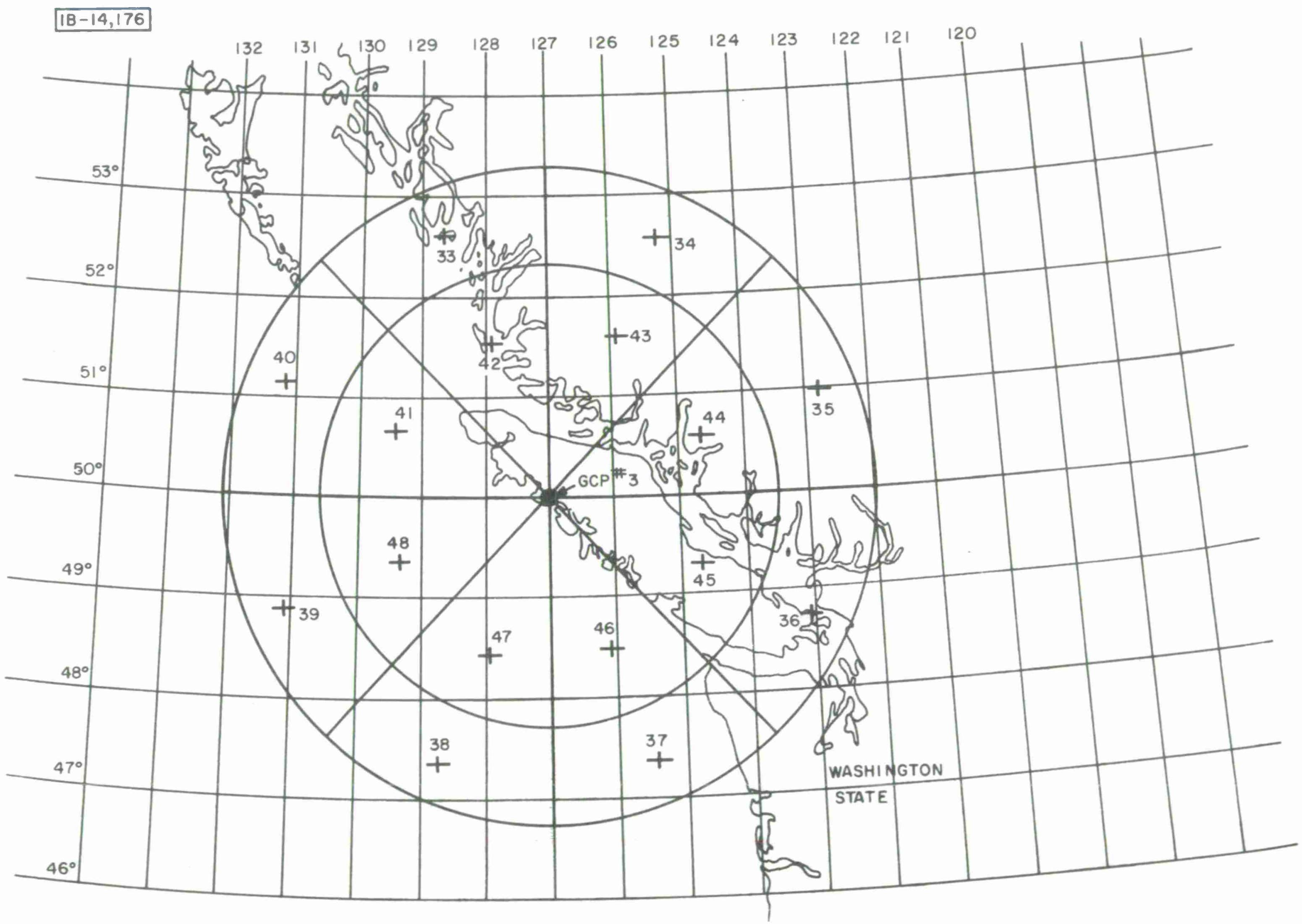


Figure 38. Ground Control Point No. 3

FRAME 106 BASES 1401 1500MILES FROM PT01 (N4743 W 6224)

BASE	LAT	LONG	RANGE	B52 MAINT	B58 MAINT	FRAME
MEMPHNAS	N 3521	W 8952	1408	NO	NO	FRAME 107
BLYTHEVI	N 3557	W 8957	1408	YES	NO	FRAME 108
MOODY	N 3059	W 8312	1408	NO	NO	FRAME 109
MEMPHMUN	N 3504	W 8958	1408	NO	NO	FRAME 110
GRANDFOR	N 4756	W 9706	1418	NO	YES	FRAME 111
MAXWELL	N 3233	W 8622	1422	YES	NO	FRAME 112
CRAIG	N 3221	W 8659	1424	YES	NO	FRAME 113
DANNELLY	N 3218	W 8624	1425	NO	NO	FRAME 114
PATRICK	N 2815	W 8036	1432	NO	NO	FRAME 115
OFFUTT	N 4107	W 9555	1444	YES	NO	FRAME 116
EPPLEY	N 4118	W 9554	1447	NO	NO	FRAME 117
COLUMBUS	N 3338	W 8827	1450	YES	NO	FRAME 118
MCCOY	N 2827	W 8120	1455	YES	NO	FRAME 119
WHITEMAN	N 3843	W 9333	1459	YES	NO	FRAME 120
KANSCITY	N 3907	W 9435	1462	YES	NO	FRAME 121
ROSECRAN	N 3946	W 9455	1469	YES	NO	FRAME 122
TYNDALL	N 3004	W 8534	1486	NO	NO	FRAME 123
OLATHE	N 3850	W 9454	1500	NO	NO	FRAME 124

Figure 39. Typical Distance Frame

FRAME #121

INDIVIDUAL BASE CAPABILITY

BASE NAME - KANSCITY LATITUDE - N3907 LONGITUDE - W09435

	BASE INVENTORY	SUMMARY FRAME NUMBER FOR PARTICULAR CAPABILITY (TO BE UPDATED IF NECESSARY)
	B52 MAINTENANCE - NO	B52 MAINTENANCE SUMMARY - FRAME #1419
	B58 MAINTENANCE - NO	B58 MAINTENANCE SUMMARY - FRAME #1419
1	1. BASE STATUS (OPEN = 1 CLOSED = 0)	BASE STATUS SUMMARY - FRAME #1419
12	2. # of B52 TURNAROUND CAPABILITIES	B52 TURNAROUND CAPABILITY SUMMARY - FRAME #1419
16	3. # of B58 TURNAROUND CAPABILITIES	B58 TURNAROUND CAPABILITY SUMMARY - FRAME #1419
4	4. # of B52 CREWS AVAILABLE	B52 CREW SUMMARY - FRAME #1419
0	5. # of B58 CREWS AVAILABLE	B58 CREW SUMMARY - FRAME #1419
6577	6. FUEL AVAILABLE - IN POUNDS X1000	
1	7. WEAPONS AVAILABLE YES = 1 NO = 0	INDIVIDUAL BASE WEAPON CAPABILITY SEE FRAME #1525
0	8. # of AIRCRAFT ON BOARD	

Figure 40. Typical Individual Base Capability Frame

FRAME #1419

BASE CAPABILITIES SUMMARY

56	1.	TOTAL NUMBER OF BASES OPERATIONAL
165	2.	TOTAL NUMBER OF BASES DESTROYED
32	3.	TOTAL NUMBER OF B52 MAINTENANCE BASES OPERATIONAL
24	4.	TOTAL NUMBER OF B58 MAINTENANCE BASES OPERATIONAL
110	5.	TOTAL NUMBER OF B52 TURNAROUND CAPABILITIES
29	6.	TOTAL NUMBER OF B58 TURNAROUND CAPABILITIES
7	7.	TOTAL NUMBER OF B52 CREWS AVAILABLE
0	8.	TOTAL NUMBER OF B58 CREWS AVAILABLE

Figure 41. Typical Base Capabilities Summary

FRAME #1525

INDIVIDUAL BASE WEAPON CAPABILITY

BASE NAME - KANSCITY

17	1. NUMBER OF 1 MEGATON WEAPONS AVAILABLE
4	2. NUMBER OF 2 MEGATON WEAPONS AVAILABLE
0	3. NUMBER OF 3 MEGATON WEAPONS AVAILABLE
0	4. NUMBER OF 4 MEGATON WEAPONS AVAILABLE
26	5. NUMBER OF 5 MEGATON WEAPONS AVAILABLE
0	6. NUMBER OF 6 MEGATON WEAPONS AVAILABLE
0	7. NUMBER OF 7 MEGATON WEAPONS AVAILABLE
0	8. NUMBER OF 8 MEGATON WEAPONS AVAILABLE
0	9. NUMBER OF 9 MEGATON WEAPONS AVAILABLE
0	10. NUMBER OF 10 MEGATON WEAPONS AVAILABLE

WEAPON SUMMARY FRAME
FOR ALL WEAPON TYPES
FRAME #1661
(TO BE UPDATED IF NEC-
CESSARY)

Figure 42. Typical Individual Base Weapon Capability

FRAME #4

INDIVIDUAL BASE CAPABILITY

BASE NAME - LORING   LATITUDE - N 4657   LONGITUDE - W 06753

	BASE INVENTORY	SUMMARY FRAME NUMBER FOR PARTICULAR CAPABILITY (TO BE UPDATED IF NECESSARY)
	B52 MAINTENANCE - NO	B52 MAINTENANCE SUMMARY FRAME - #1419
	B58 MAINTENANCE - YES	B58 MAINTENANCE SUMMARY FRAME - #1419
1	1. BASE STATUS (OPEN = 1 CLOSED = 0)	BASE STATUS SUMMARY - FRAME #1419
26	2. # of B52 TURNAROUND CAPABILITIES	B52 TURNAROUND CAPABILITY SUMMARY – FRAME #1419
17	3. # of B58 TURNAROUND CAPABILITIES	B58 TURNAROUND CAPABILITY SUMMARY – FRAME #1419
8	4. #of B52 CREWS AVAILABLE	B52 CREW SUMMARY - FRAME #1419
2	5. #of B58 CREWS AVAILABLE	B58 CREW SUMMARY - FRAME #1419
1389	6. FUEL AVAILABLE - IN POUNDS	
1	7. WEAPONS AVAILABLE YES = 1 NO = 0	INDIVIDUAL BASE WEAPON CAPABILITY SEE FRAME #1420
11	8. # of AIRCRAFT ON BOARD	

Figure 43. Update Associated with Base Destruction Report

FRAME #1420

INDIVIDUAL BASE WEAPON CAPABILITY

BASE NAME - LORING

1. NUMBER OF 1 MEGATON WEAPONS AVAILABLE
2. NUMBER OF 2 MEGATON WEAPONS AVAILABLE
3. NUMBER OF 3 MEGATON WEAPONS AVAILABLE
4. NUMBER OF 4 MEGATON WEAPONS AVAILABLE
5. NUMBER OF 5 MEGATON WEAPONS AVAILABLE
6. NUMBER OF 6 MEGATON WEAPONS AVAILABLE
7. NUMBER OF 7 MEGATON WEAPONS AVAILABLE
8. NUMBER OF 8 MEGATON WEAPONS AVAILABLE
9. NUMBER OF 9 MEGATON WEAPONS AVAILABLE
10. NUMBER OF 10 MEGATON WEAPONS AVAILABLE

WEAPON SUMMARY FRAME
FOR ALL WEAPON TYPES
FRAME #1661
(TO BE UPDATED IF NEC-
CESSARY)

Figure 44. Update Associated with Base Weapon Destruction

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) The MITRE Corporation Bedford, Mass.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Support System Division, Deputy for Advanced Planning. Electronic Systems Division, L. G. Hanscom Field, Bedford, Mass.

13. ABSTRACT

This document describes the development of the concept of "Dynamic Update of a Microfilm File." Included is a complete description of the prototype hardware that was designed and fabricated to prove the feasibility of combining magnetic and photographic techniques of information storage. The prototype hardware possesses the capability of information storage, rapid update, retrieval and display.

DD FORM 1 JAN 64 1473

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Photographic Recording Media						
Microfilm						
Information Retrieval						
Information Storage						

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